NASA Mission Management Updates to the *Hinode* Science Working Group

September 2016

On behalf of the US instrument teams

Focused Mode Coordination

- Status: Operable
  - No major issues reported from the teams.
  - Plans for QS conditions not completely resolved

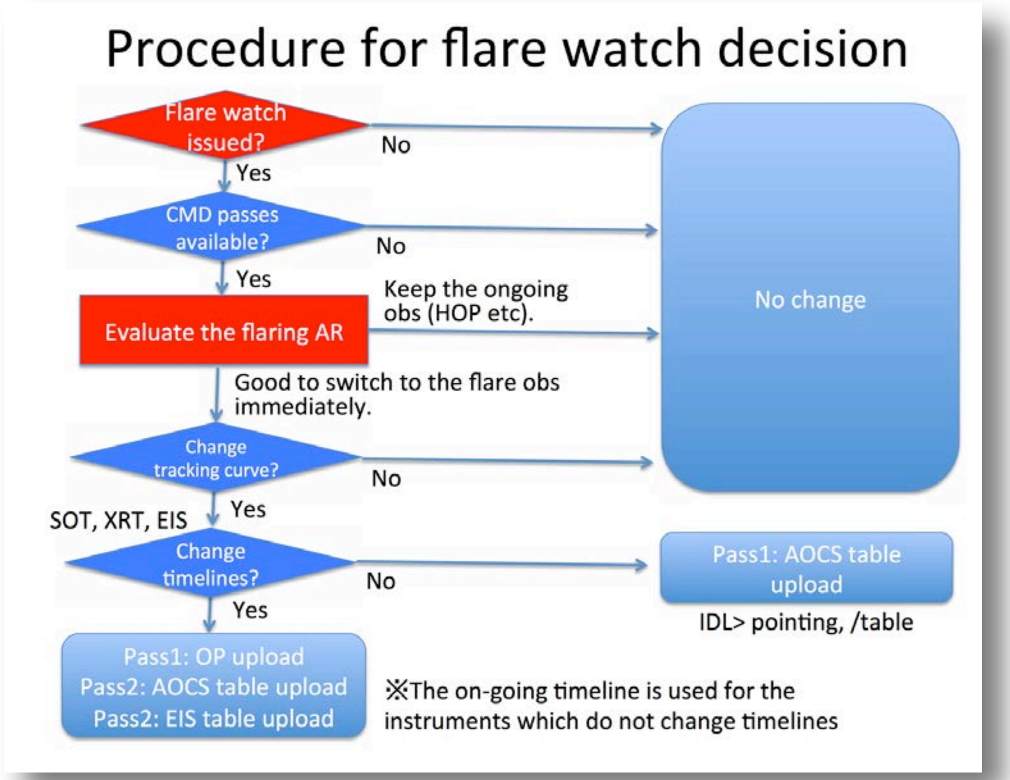
- Reminder for Focused Mode HOPs sent to community via SolarNews.
  - (released Sept 1, 2016)

- Focused Mode coordination
  - Focused Mode Liaison not used since last SWG
    - Relying on weekly instrument team meetings for communication

  - Priority list circulating with weekly meetings
    - Active Region evolution (flux emergence, waves in sunspots, flare monitoring)
    - Coronal Holes
    - Prominence / Filament
    - Disk-center (long baseline synoptic scans)
    - Polar magnetic network

Focused Mode Coordination

- Flare WatchDog
  - Yumi Bamba-san has been filling this position very well. Has now graduated, but still working with the mission.
    - Talk on
  - Suggestions for successor for uptick in activity…eventually? Continue with a graduate student?



Focused Mode Calendar

2016

January

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February

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June

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July

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August

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September

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25	26	27	28	29	30	31

- Focused Mode (Tuesday upload only)
- Normal (Tuesday, Thursday, Saturday uploads)
- IRIS Coordination
- IRIS Eclipse
- Hinode Eclipse
- Rocket Launch / Notable Campaign

Focused Mode Calendar

PROPOSED PROPOSED PROPOSED **2017** PROPOSED PROPOSED PROPOSED

January

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Focused Mode (Tuesday upload only)

Holiday period; standard FM

Normal (Tuesday, Thursday, Saturday uploads)

Nominal IRIS Coordination

IRIS Eclipse

Hinode Eclipse

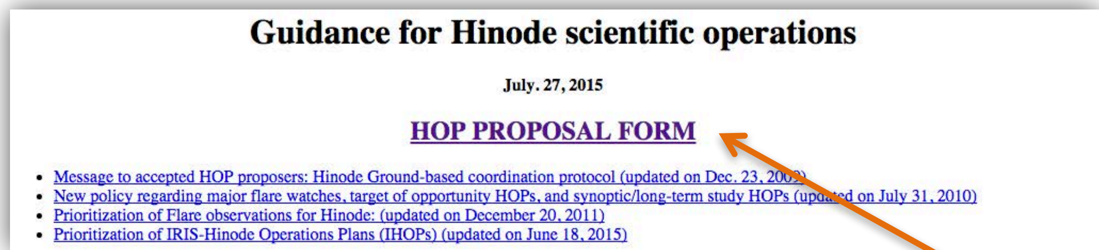
Rocket Launch / Notable Campaign

***** Hi-C II launch in July? ***; Other launches / campaigns?**

November 23rd is Thanksgiving week (less US support already). FM during Dec/Jan holidays.

HOPs

Lead HOP information site: http://www.isas.jaxa.jp/home/solar/guidance/index.html


Guidance for Hinode scientific operations

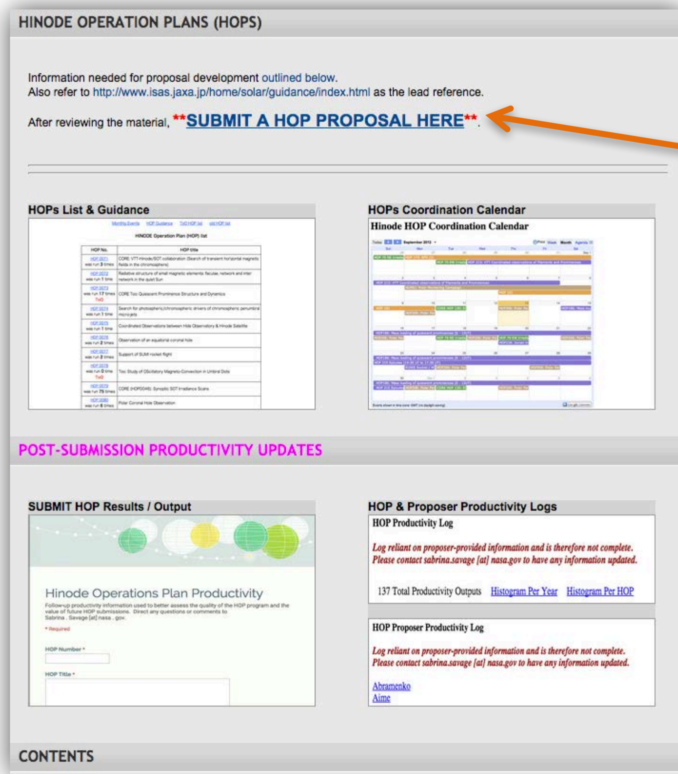
July. 27, 2015

HOP PROPOSAL FORM

- Message to accepted HOP proposers: Hinode Ground-based coordination protocol (updated on Dec. 23, 2009)
- New policy regarding major flare watches, target of opportunity HOPs, and synoptic/long-term study HOPs (updated on July 31, 2010)
- Prioritization of Flare observations for Hinode: (updated on December 20, 2011)
- Prioritization of IRIS-Hinode Operations Plans (IHOPs) (updated on June 18, 2015)

Submission Form: https://docs.google.com/forms/d/1mvUqVsIlEZ0ta4hbzkVqKKv_kW8x6IHI584IkvaOzX8/viewform

NASA HOP information site: http://hinode.msfc.nasa.gov/hops.html


HINODE OPERATION PLANS (HOPS)

Information needed for proposal development outlined below.
Also refer to http://www.isas.jaxa.jp/home/solar/guidance/index.html as the lead reference.

After reviewing the material, **SUBMIT A HOP PROPOSAL HERE**.

HOPs List & Guidance

HOPs Coordination Calendar

Hinode HOP Coordination Calendar

POST-SUBMISSION PRODUCTIVITY UPDATES

SUBMIT HOP Results / Output

Hinode Operations Plan Productivity

HOP & Proposer Productivity Logs

HOP Productivity Log

Log reliant on proposer-provided information and is therefore not complete. Please contact sabrina.savage [at] nasa.gov to have any information updated.

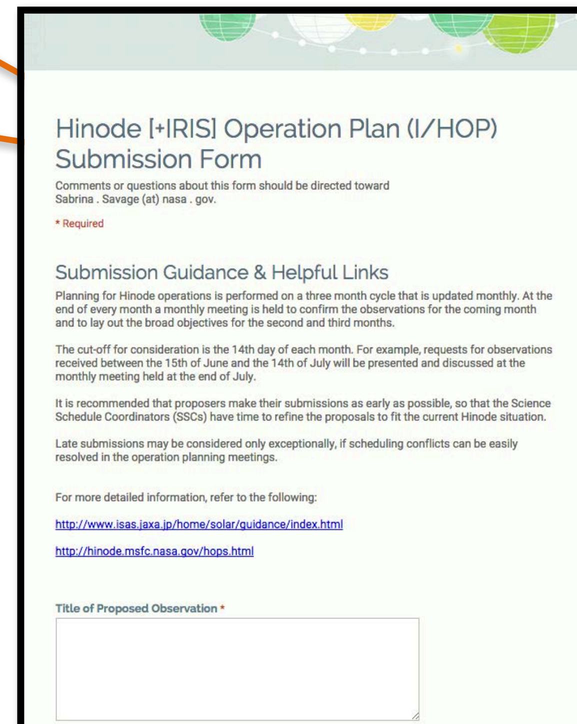
137 Total Productivity Outputs Histogram Per Year Histogram Per HOP

HOP Proposer Productivity Log

Log reliant on proposer-provided information and is therefore not complete. Please contact sabrina.savage [at] nasa.gov to have any information updated.

Abramenko
Aime

CONTENTS


Hinode [+IRIS] Operation Plan (I/HOP) Submission Form

Comments or questions about this form should be directed toward Sabrina . Savage (at) nasa . gov.

* Required

Submission Guidance & Helpful Links

Planning for Hinode operations is performed on a three month cycle that is updated monthly. At the end of every month a monthly meeting is held to confirm the observations for the coming month and to lay out the broad objectives for the second and third months.

The cut-off for consideration is the 14th day of each month. For example, requests for observations received between the 15th of June and the 14th of July will be presented and discussed at the monthly meeting held at the end of July.

It is recommended that proposers make their submissions as early as possible, so that the Science Schedule Coordinators (SSCs) have time to refine the proposals to fit the current Hinode situation.

Late submissions may be considered only exceptionally, if scheduling conflicts can be easily resolved in the operation planning meetings.

For more detailed information, refer to the following:

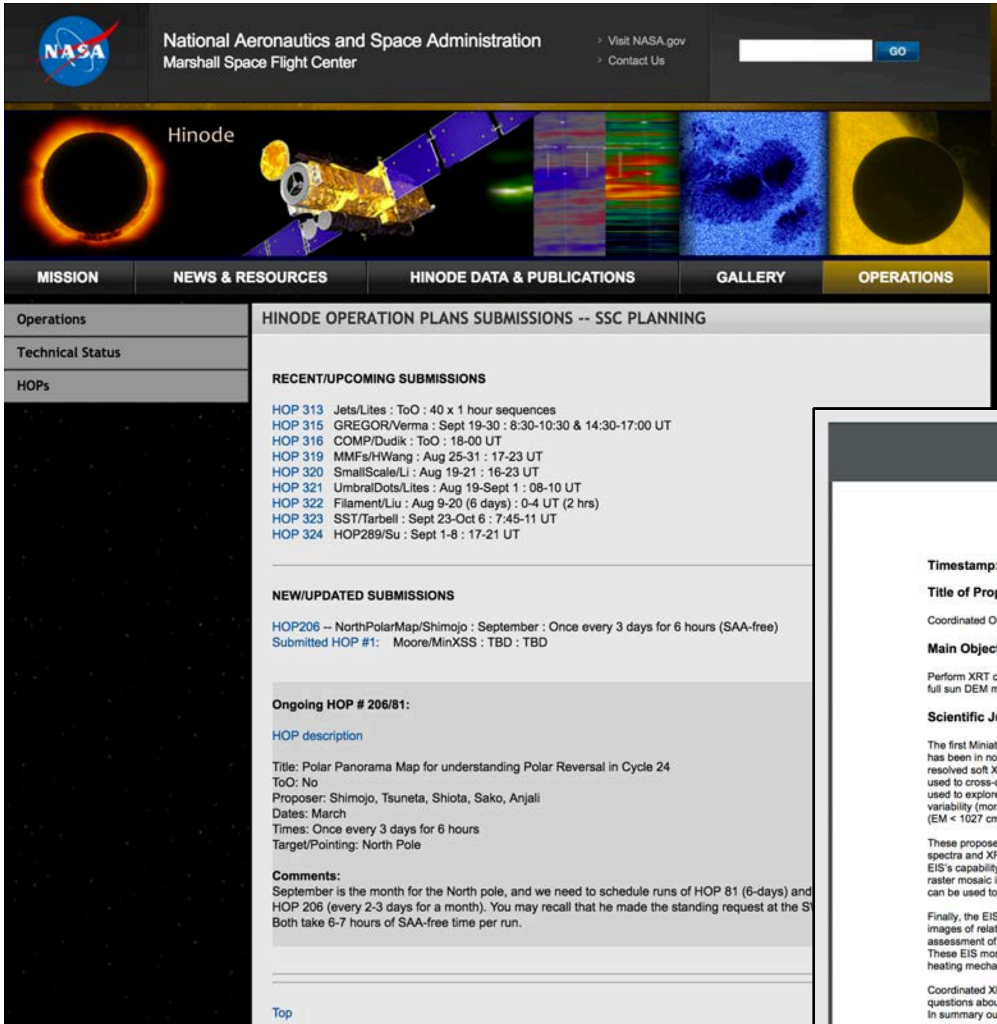
http://www.isas.jaxa.jp/home/solar/guidance/index.html

http://hinode.msfc.nasa.gov/hops.html

Title of Proposed Observation *

HOPs

SSC planning site: http://hinode.msfc.nasa.gov/submitted_hops.html



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Hinode

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Operations
Technical Status
HOPs

HINODE OPERATION PLANS SUBMISSIONS -- SSC PLANNING

RECENT/UPCOMING SUBMISSIONS

HOP 313 Jets/Lites : ToO : 40 x 1 hour sequences
HOP 315 GREGOR/Verma : Sept 19-30 : 8:30-10:30 & 14:30-17:00 UT
HOP 316 COMP/Dudik : ToO : 18-00 UT
HOP 319 MMFs/HWang : Aug 25-31 : 17-23 UT
HOP 320 SmallScale/Li : Aug 19-21 : 16-23 UT
HOP 321 UmbralDots/Lites : Aug 19-Sept 1 : 08-10 UT
HOP 322 Filament/Liu : Aug 9-20 (6 days) : 0-4 UT (2 hrs)
HOP 323 SST/Tarbell : Sept 23-Oct 6 : 7:45-11 UT
HOP 324 HOP289/Su : Sept 1-8 : 17-21 UT

NEW/UPDATED SUBMISSIONS

HOP206 -- NorthPolarMap/Shimojo : September : Once every 3 days for 6 hours (SAA-free)
Submitted HOP #1: Moore/MinXSS : TBD : TBD

Ongoing HOP # 206/81:

HOP description

Title: Polar Panorama Map for understanding Polar Reversal in Cycle 24
ToO: No
Proposer: Shimojo, Tsuneta, Shiota, Sako, Anjali
Dates: March
Times: Once every 3 days for 6 hours
Target/Pointing: North Pole

Comments:
September is the month for the North pole, and we need to schedule runs of HOP 81 (6-days) and
HOP 206 (every 2-3 days for a month). You may recall that he made the standing request at the S
Both take 6-7 hours of SAA-free time per run.

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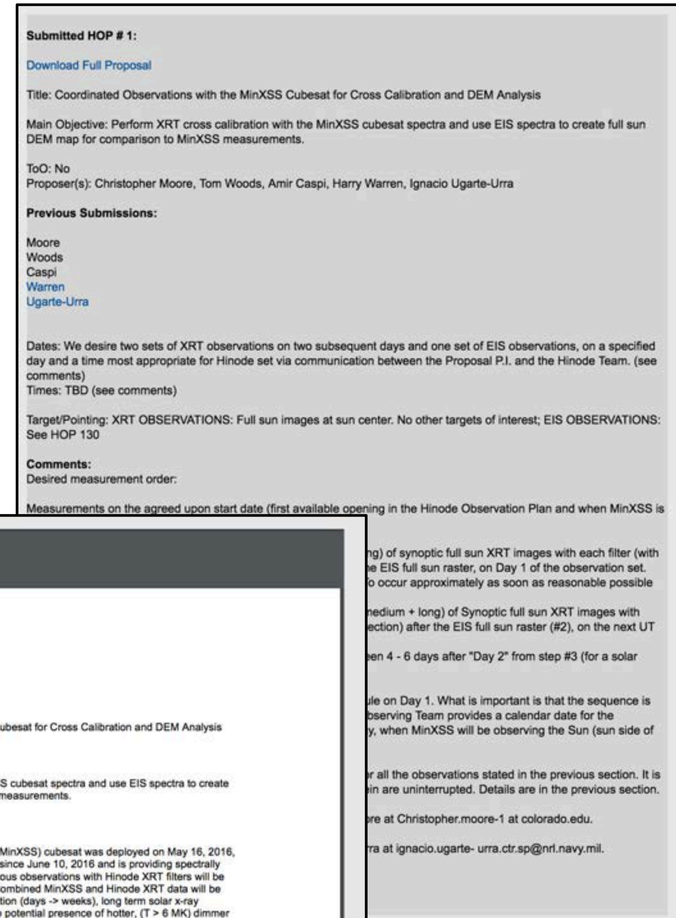


Submitted HOP # 1:

Download Full Proposal

Title: Coordinated Observations with the MinXSS Cubesat for Cross Calibration and DEM Analysis

Main Objective: Perform XRT cross calibration with the MinXSS cubesat spectra and use EIS spectra to create full sun DEM map for comparison to MinXSS measurements.

ToO: No
Proposer(s): Christopher Moore, Tom Woods, Amir Caspi, Harry Warren, Ignacio Ugarte-Urra

Previous Submissions:

Moore
Woods
Caspi
Warren
Ugarte-Urra

Dates: We desire two sets of XRT observations on two subsequent days and one set of EIS observations, on a specified day and a time most appropriate for Hinode set via communication between the Proposal P.I. and the Hinode Team. (see comments)
Times: TBD (see comments)

Target/Pointing: XRT OBSERVATIONS: Full sun images at sun center. No other targets of interest; EIS OBSERVATIONS: See HOP 130

Comments:
Desired measurement order:

Measurements on the agreed upon start date (first available opening in the Hinode Observation Plan and when MinXSS is

ng) of synoptic full sun XRT images with each filter (with
e EIS full sun raster, on Day 1 of the observation set.
o occur approximately as soon as reasonable possible

edium + long) of Synoptic full sun XRT images with
ection) after the EIS full sun raster (#2), on the next UT

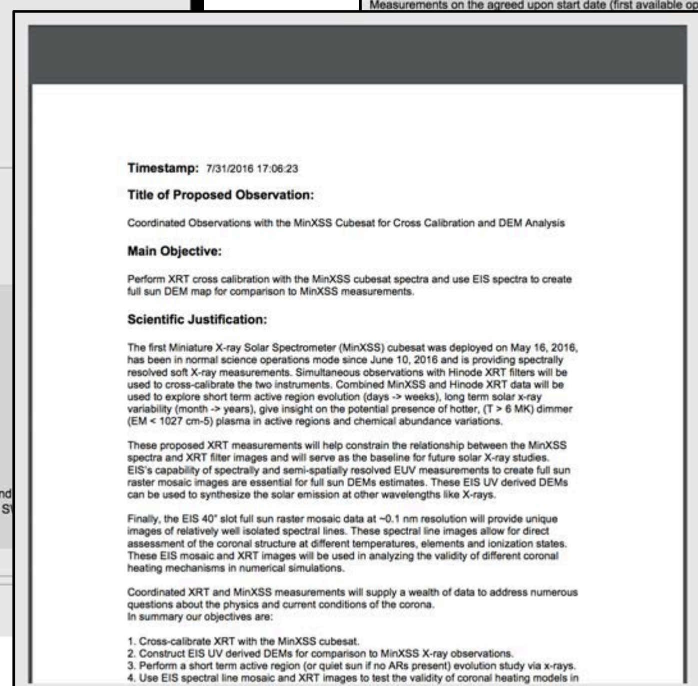
en 4 - 6 days after "Day 2" from step #3 (for a solar

le on Day 1. What is important is that the sequence is
bserving Team provides a calendar date for the
y, when MinXSS will be observing the Sun (sun side of

r all the observations stated in the previous section. It is
in are uninterrupted. Details are in the previous section.

re at Christopher.moore-1 at colorado.edu.

ra at ignacio.ugarte- urra.ctr.sp@nrl.navy.mil.



Timestamp: 7/31/2016 17:06:23

Title of Proposed Observation:

Coordinated Observations with the MinXSS Cubesat for Cross Calibration and DEM Analysis

Main Objective:

Perform XRT cross calibration with the MinXSS cubesat spectra and use EIS spectra to create full sun DEM map for comparison to MinXSS measurements.

Scientific Justification:

The first Miniature X-ray Solar Spectrometer (MinXSS) cubesat was deployed on May 16, 2016, has been in normal science operations mode since June 10, 2016 and is providing spectrally resolved soft X-ray measurements. Simultaneous observations with Hinode XRT filters will be used to cross-calibrate the two instruments. Combined MinXSS and Hinode XRT data will be used to explore short term active region evolution (days -> weeks), long term solar x-ray variability (month -> years), give insight on the potential presence of hotter, (T > 6 MK) dimmer (EM < 1027 cm-5) plasma in active regions and chemical abundance variations.

These proposed XRT measurements will help constrain the relationship between the MinXSS spectra and XRT filter images and will serve as the baseline for future solar X-ray studies. EIS's capability of spectrally and semi-spatially resolved EUV measurements to create full sun raster mosaic images are essential for full sun DEMs estimates. These EIS UV derived DEMs can be used to synthesize the solar emission at other wavelengths like X-rays.

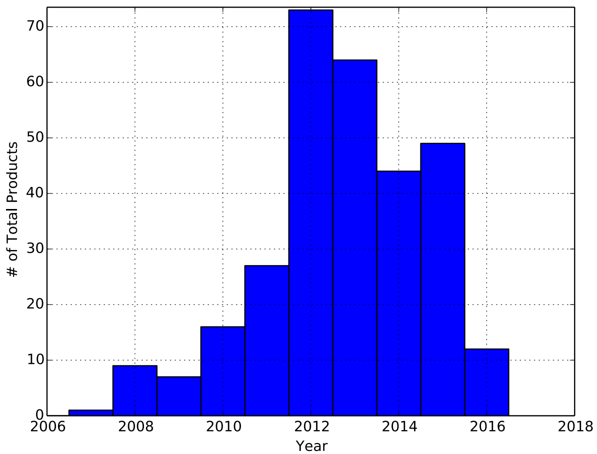
Finally, the EIS 40" slot full sun raster mosaic data at ~0.1 nm resolution will provide unique images of relatively well isolated spectral lines. These spectral line images allow for direct assessment of the coronal structure at different temperatures, elements and ionization states. These EIS mosaic and XRT images will be used in analyzing the validity of different coronal heating mechanisms in numerical simulations.

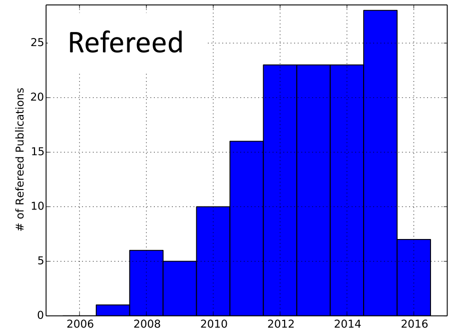
Coordinated XRT and MinXSS measurements will supply a wealth of data to address numerous questions about the physics and current conditions of the corona.
In summary our objectives are:

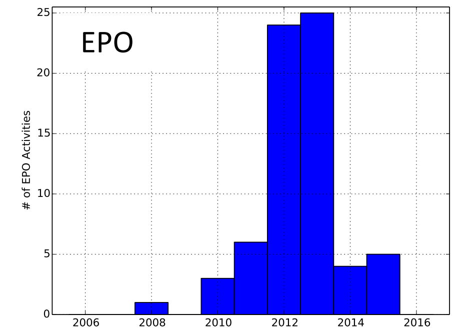
1. Cross-calibrate XRT with the MinXSS cubesat.
2. Construct EIS UV derived DEMs for comparison to MinXSS X-ray observations.
3. Perform a short term active region (or quiet sun if no ARs present) evolution study via x-rays.
4. Use EIS spectral line mosaic and XRT images to test the validity of coronal heating models in

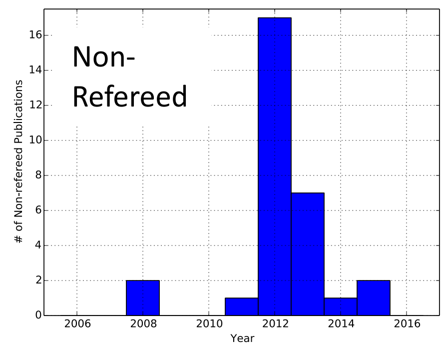
HOPs

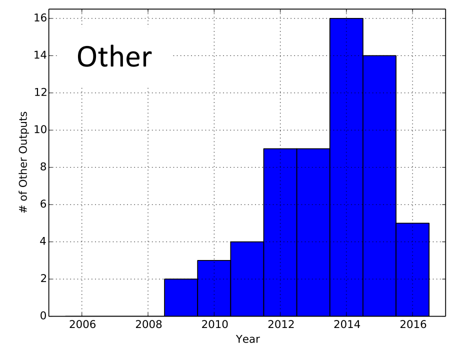
Total Products Per Year



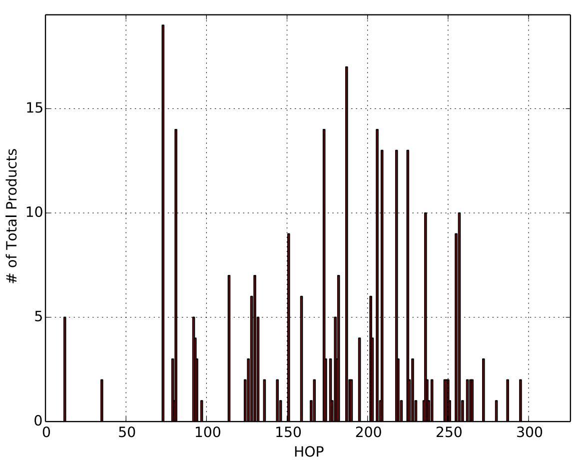








Total Products Per HOP



Current report (as of Sept. 2, 2016):

91 HOPs reporting (~28% for HOPs 72-325 & 2 < 71)
251* Total Productivity Outputs
123 Refereed Publications
20 Non-refereed Publications [e.g., Conf. Proceedings]
46 EPO Activities
62 Other Outputs [e.g., Talks, Posters]

Have not sent out a call yet this year.

*Total slightly below last year's report due to duplicated N-r pubs & EPO submissions discovered.

HOPs

A. Kobelski put together a table characterizing the target study and coordination for each HOP (from 71).

HOP_Number	QS	AR	Coronal_Hole	Pole	Disk_Center	Whole_Disk/Synoptic	at/off-limb	Sunspot	Dopplergram	Magnetic_Field	Vector_Magnetic_Field	Bright_Points	Jets	dynamo/convection/network	Emerging/Submerging_Flux	Coronal_Rain	Tornado
71	1	1	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0
72	1	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
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77	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
78	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
79	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
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113	0	1	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
114	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
115	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
116	0	1	1	0	1	1	0	0	0	1	0	0	0	0	0	0	0
117	1	1	0	0	0	0	0	1	0	1	1	1	0	0	0	0	0
118	1	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0
119	1	1	0	0	0	0	0	0	0	1	1	0	0	0	1	0	0
120	0	1	0	0	1	0	0	1	0	1	1	0	0	1	1	0	0
121	0	1	0	0	0	0	1	0	0	1	1	0	0	0	0	0	0
122	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

HOP_Number	Prominence/Filament	Spicules	Waves/Oscillations	Helioseismology	Plumes	Chromosphere/TR	Solar_Wind	nano/microflares/ARTBs	Flares	CMEs	Transit	Eclipse	Comet	Sounding Rocket/Balloon	Calibration/Engineering	EIS	SOT	XRT	IRIS	coordination
71	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	1	0	VTT
72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0	SST; DOT
73	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	SST; DOT
74	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	1	0	SST
75	1	1	1	0	0	1	0	0	1	0	0	0	0	0	0	1	2	1	0	Hida
76	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	2	2	0	
77	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	2	2	2	0	SUMI
78	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	Hida
79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	
80	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	SUMER
81	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	2	2	0	
82	1	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2	2	2	0	SUMER
83	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2	2	1	0	
84	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	
85	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	2	1	0	SUMER
86	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2	2	0	SUMER
87	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	
88	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	1	1	0	KOS
89	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2	2	1	0	IBIS
90	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	2	0	BBSO
91	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	1	2	0	
92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	
93	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	2	2	0	SUMER
94	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	2	2	0	
95	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	
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97	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	1	2	0	
98	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	2	2	2	0	
99	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1	0	ROSA; IBIS
100	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2	2	2	0	
101	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	
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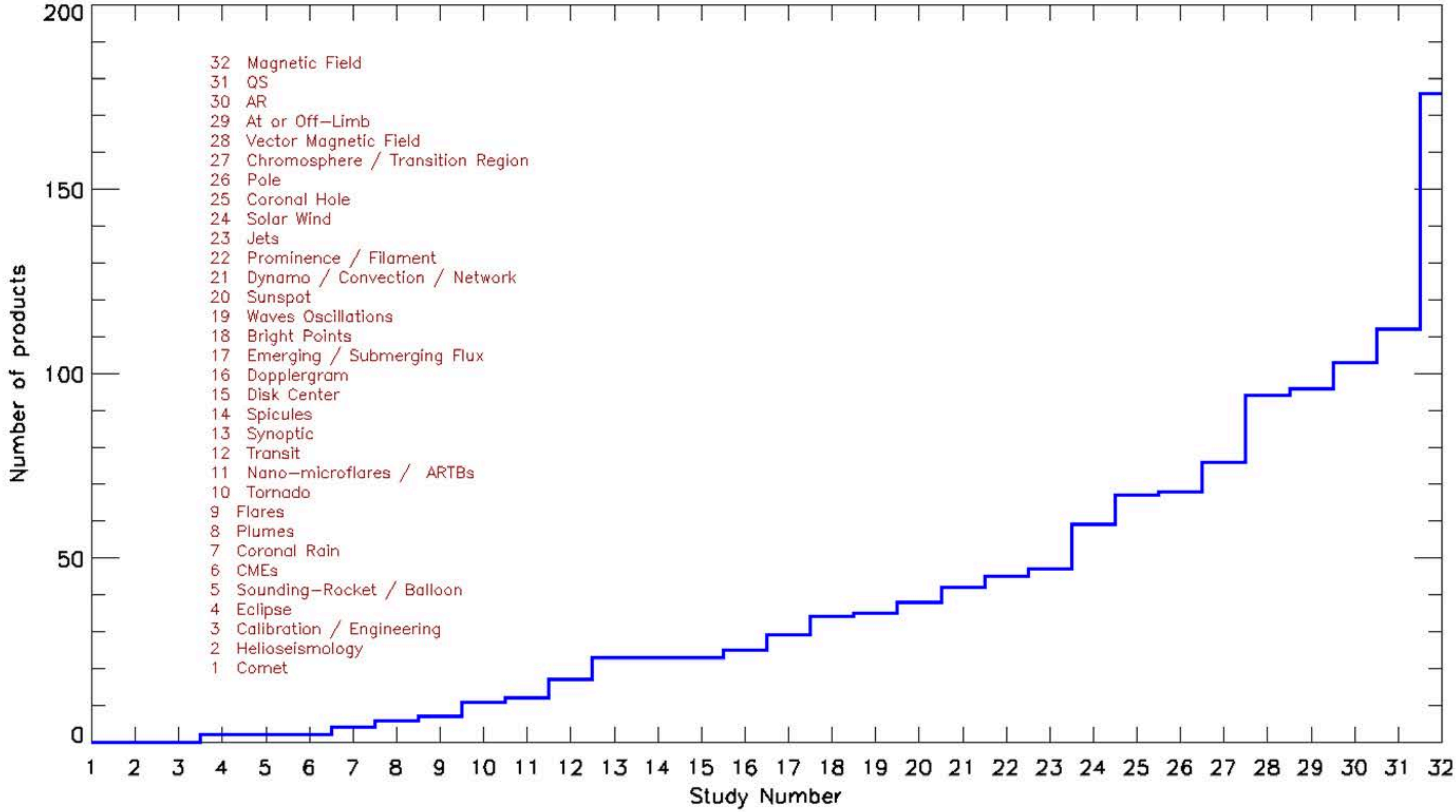
104	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	2	0	0	0	SUMER
105	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	SUMER
106	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	1	2	1	0	SUMER
107	0	0	1	0	1	0	1	0	0	0	0	0	0	0	0	2	0	1	0	SUMER
108	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	2	2	2	0	SUMER
109	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	SUMER
110	0	1	1	0	0	1	1	1	0	0	0	0	0	0	0	2	2	1	0	SUMER
111	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	TRACE; SoHO/SUMER and CDS; Stereo; Meudon Solar Tower; Ondrejov; Bialkow; THEMIS
112	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	2	2	1	0	SUMER; ROSA; IBIS
113	0	1	1	1	0	1	0	0	0	0	0	0	0	0	0	2	2	1	0	SUMER; ROSA; IBIS
114	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	1	0	MLSO/COMP
115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	PIC du Midi
116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	CORONAS-TESIS
117	0		0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	1	0	IBIS
118	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	SHAZAM
119	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	2	0	0	CRISP
120	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	1	2	1	0	Sunrise; VTT; SST; DOT; DST
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	CORONAS-TESIS
122	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

HOPs

I combine the study table with the product output information for each HOP (not just refereed papers!). Incomplete due to not having information for each HOP (e.g., eclipses, SRs) and needs some closer inspection per HOP, but it's a decent first order proxy for assessing what Hinode has been most successful at observing thus far. Shows the richness of the campaigns.



HOP Coordinations

Hinode regularly coordinates with both ground- and space-based observatories and complements several regularly scheduled data-collecting observatories(*) . Hinode also co-observes with sounding rocket and balloon technology development demonstrations. Much of the coordination is scheduled through the Hinode Operations Plan (HOP) program. Since 2008, partnering sites and instrumentation include (but not limited to):

Ground-based:

Atacama Large Millimeter/Submillimeter Array (ALMA) – Chile
Bialkow Observatory – Poland
Big Bear Solar Observatory (BBSO) [NST/FISS/IRIM] – New Jersey
Dunn Solar Telescope (DST/NSO) [IBIS/ROSA/SHAZAM/FIRS] – New Mexico
Dutch Open Telescope (DOT) – La Palma
Fuxian Lake Solar Observatory [NVST] – China
GREGOR Solar Telescope [GRIS] – Tenerife
Haleakala Observatory – Hawaii
Hida Observatory [DST] – Japan
Iitate Radio Telescope (IPRT) – Tohoku University/Japan
Kanzelhohe Solar Observatory (KSO) – Austria
Lomnicky Peak Observatory [CoMP] – Czech Republic
Mauna Loa Solar Observatory (MLSO) [CoMP] – Hawaii
McMath-Pierce Telescope (NSO) – New Mexico
Meudon Solar Tower – Paris
Ondrejov Observatory – Czech Republic
Pic du Midi Observatory – France
Solar Magnetic Activity Research Telescope (SMART) – Japan
Solar Terrestrial Laboratory [IPS] – Nagoya University/Japan
Solar Tower Telescope of Nanjing University – China
Swedish Solar Telescope (SST) [CRISP/TRIPPEL] – La Palma
Synoptic Optical Long-term Investigations of the Sun (SOLIS/NSO) – New Mexico
Vacuum Tower Telescope (VTT) – Tenerife
Very Large Array (VLA)

(Note: Several High Schools and Science Museums in Japan)

Space-based:

Active Cavity Radiometer Irradiance Monitor Satellite (ACRIM)
*Advanced Composition Explorer (ACE)
Akatsuki (Venus probe)
Cassini (Saturn mission)
Hubble Space Telescope (HST) [WFPC3]
Interface Region Imaging Spectrograph (IRIS)
Mercury Surface, Space Environment, Geochemistry, and Ranging (Mercury mission)
Nuclear Spectroscopic Telescope Array (NuSTAR)
Project for OnBoard Autonomy 2 (PROBA2) [SWAP]
*Ramaty High Energy Solar Spectroscopic Imager (RHESSI)
Solar and Heliospheric Observatory (SOHO) [SUMER/EIT/CDS/UVCS/MDI/LASCO]
*Solar Dynamics Observatory (SDO) [AIA/EVE/HMI/MinXSS]
Solar Radiation and Climate Experiment (SORCE) [TIM]
*Solar Terrestrial Relations Observatory (STEREO) [EUVI]
Telescopes for EUV Spectral Imaging of the Sun (TESIS) [CORONAS]
Time History of Events and Macroscale Interactions during Substorms (THEMIS)
Transient Region and Coronal Explorer (TRACE)
*Wind: Comprehensive Solar Wind Laboratory for Long-Term Solar Wind Measurements

Technology Demonstrations:

SUMI
RAISE
SUNRISE (Balloon)
EUNIS
HIC (1, 2)
FOXSI
VERIS
MOSES (1 & 2)
VAULT
CLASP

52 Total Observatories/Rockets/Balloons; at least 69 instrument coordinations

NASA situation

Senior Review Upcoming **(early this year to line up with NASA budget reviews)**

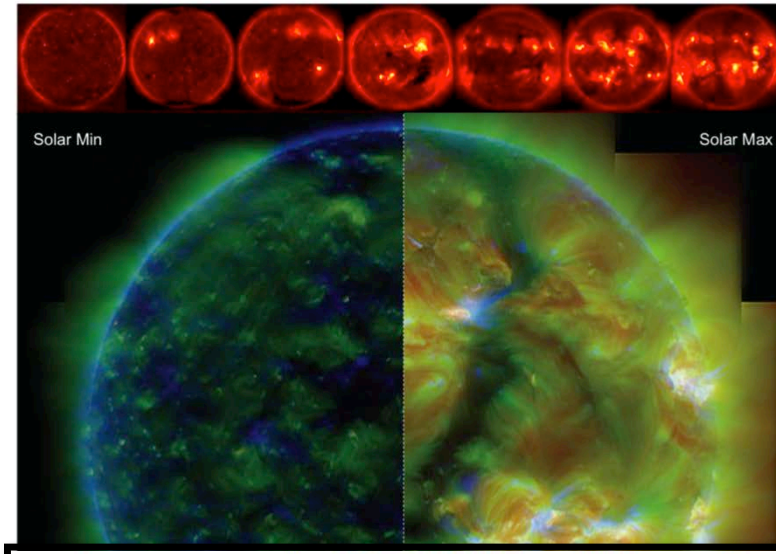
Announcement of Opportunity expected within the next month
Presentation to Panel ~March 2017
Results ~May 2017

Need to:

Schedule US team meeting at Hinode 10.
Set Prioritized Science Goals for the next few years.
Determine sufficiency of response to previous PSGs.
Pull together impactful coordinated observations (IRIS, NuSTAR, ALMA).
Send out call for HOP outputs.

2-3. Hinode Scientific Activities

Hinode: A Comprehensive Mission to Study the Variable Sun



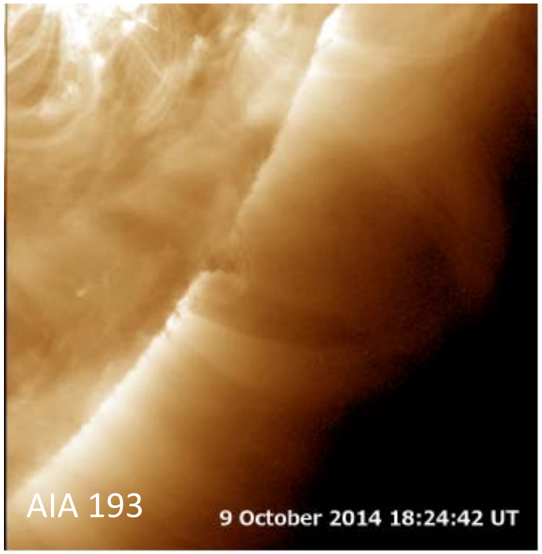
In response to the 2012 NRC Decadal Survey Science Challenges and 2014 Heliophysics Roadmap Research Focus Areas, the *Hinode* mission has set forth four **Prioritized Science Goals (PSGs)**:

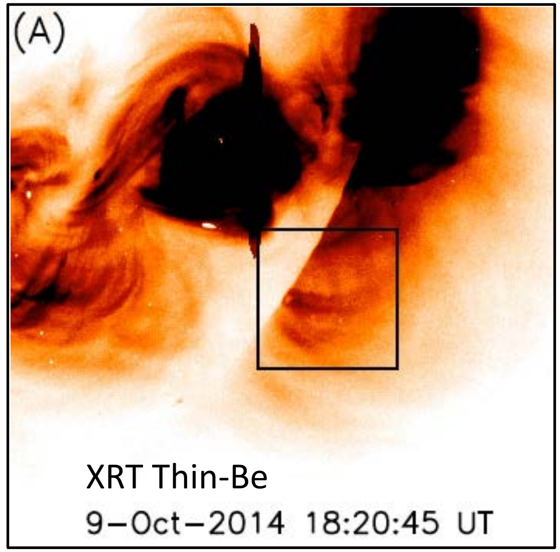
- Study the sources and evolution of highly energetic dynamic events.
- Characterize cross-scale magnetic field topology and stability.
- Trace mass and energy flow from the photosphere to the corona.
- Continue long term synoptic support to quantify cycle variability.

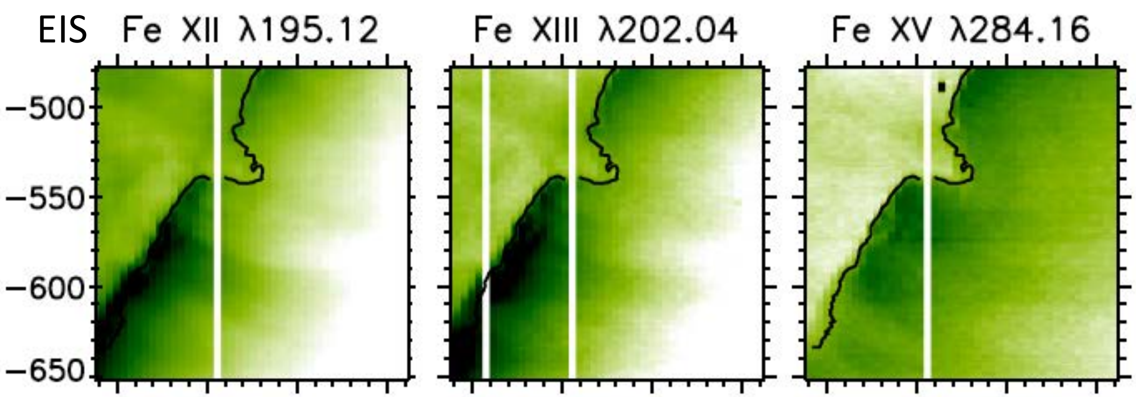
Table 2: Prioritized Science Goals and required observations mapped to the 2014 Heliophysics Roadmap Research Focus Areas (RFAs) and 2012 Decadal Survey Challenges (DSCs).

RFAs & DSCs	**§**	**SCIENCE OBJECTIVE**	**SAMPLE OBSERVATIONS**
§ 3.1: PSG1 – Study the sources and evolution of highly energetic dynamic events			
RFA H1	3.1.1	Observe large-scale eruptive events from flare to particle acceleration.	- Coordinated radio, EUV, and X-ray observations of thermal & non-thermal eruption processes
RFA F2	3.1.2	Characterize the energetics of nanoflares and properties of non-thermal electrons.	- Nanoflare electron beam studies with *NuSTAR*
RFA F1	3.1.3	Probe magnetic reconnection flux transfer and energy release during flaring events.	- Spectrally probing chromospheric evaporation/condensation in flare loops
			Focused Mode opportunity: CME watch
DSCs SH 2 & 3			**Synergies:** *IRIS*, *ALMA VLA*, *EOVSA*, *NuSTAR*, *SDO*, *RHESSI*, *STEREO*
§ 3.2: PSG2 – Characterize the cross-scale magnetic field topology and stability.			
RFA H1	3.2.1	Study active region energy storage, topology, and evolution.	- Monitor the temperature stratification above ARs to potentially predict energy releases
RFA F2	3.2.2	Determine the impact of small-scale magnetic fields on the solar atmosphere.	- Specifically-designed sequences for *IRIS* coordination to observe unresolved fine structure in the transition region
DSCs SH 2 & 3	3.2.3	Determine the impact of large-scale magnetic field variations on the heliosphere.	- Test S-web model predictions concerning magnetic field topology in the outer corona with deep, wide-field SXR imaging
			Focused Mode opportunity: AR evolution
			Synergies: *IRIS*, *SDO*
§ 3.3: PSG3 – Trace mass and energy flow from the photosphere to the corona.			
RFA H1	3.3.1	Isolate solar wind sources and measure their mass supply.	- New EIS observing modes scanning for slow solar wind sources
RFA F5	3.3.2	Characterize the heating of the chromosphere.	- Link chromospheric heating diagnostic ion transport with Poynting flux estimates
	3.3.3	Quantify the generation, dissipation, and impact of magnetic waves.	- Vorticity measurements tracing chromospheric twist into the corona
DSCs SH 2 & 3			**Focused Mode opportunity:** EIS scans
			Synergies: *ACE*, *IRIS*, *SDO*
§ 3.4: PSG4 – Continue long term synoptic support to quantify cycle variability.			
RFA F4	3.4.1	Understand solar irradiance variations.	- Derive continuum contrast from SOT continuum bands and *IRIS* Mg II index
RFA H1	3.4.2	Monitor solar cycle evolution and stability.	- Polar magnetic fields, X-ray bright points, and magnetic activity band progression as indicators of solar cycle evolution and activity
	3.4.3	Relate solar variability to stellar evolution.	- Application of "Sun-as-a-star" methods to synoptic data for stellar abundance profiles
DSCs SH 1 & 3			**Synergies:** *IRIS*, *SDO*

Hinode Highlights: Coronal Cavity Structure







- On October 9, 2014 a coronal cavity was observed by Hinode and IRIS as part of IHOP 264
- The cavity structure is clearly in the EIS Fe XII, and Fe XIII raster scans, but he cavity wall is not visible in the EIS Fe XV line, indicating that the cavity defining structures are less than ~2MK.
- The cavity is also visible in the XRT Thin-Be filter, though foreground and background loops are also visible.

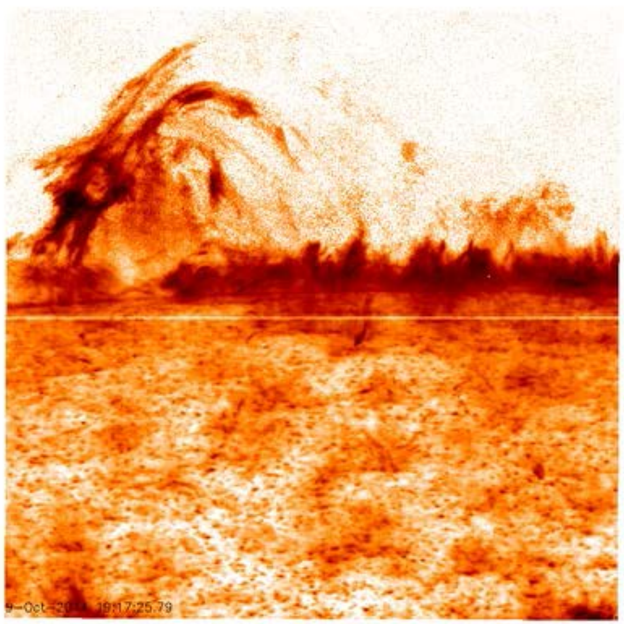
Jibben, Reeves, & Su, *Frontiers in Astronomy and Space Sciences*, submitted

Via the Hinode/XRT team through the Smithsonian Astrophysical Observatory

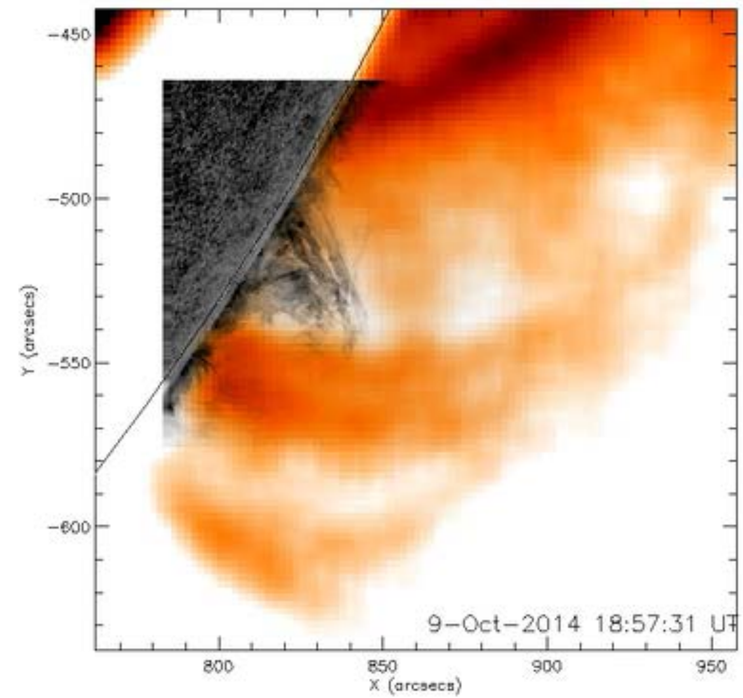
Hinode Highlights: Coronal Cavity Structure

Jibben, Reeves, & Su, *Frontiers in Astronomy and Space Sciences*, submitted

IRIS 1400 SJI



XRT (orange)
SOT (grey)

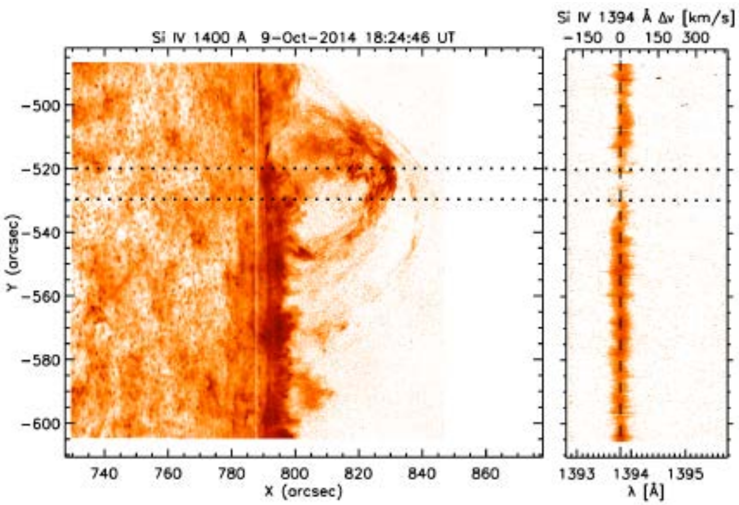


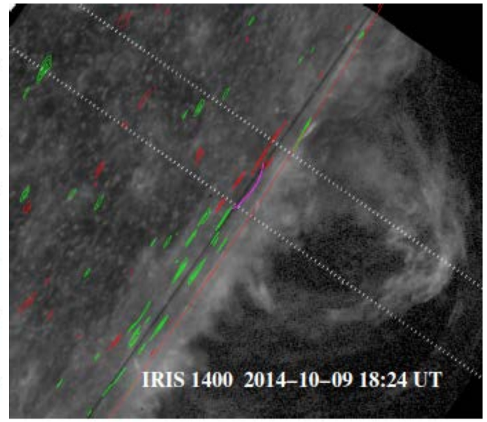
IRIS movie from the slit-jaw imager shows a disturbance that causes plasma to flow over and around the prominence, outlining the cavity structure

A combination XRT/SOT movie shows that an incursion of hot plasma from the north is responsible for the disturbance. XRT data also indicates heating around the tip of the prominence

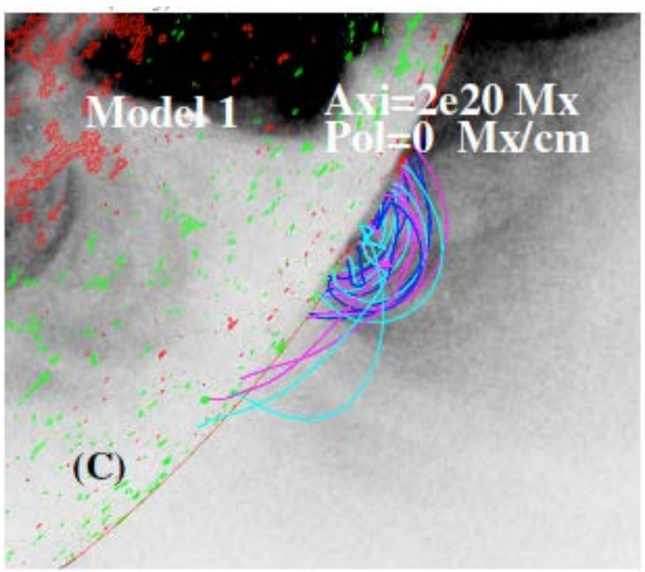
Via the Hinode/XRT team through the Smithsonian Astrophysical Observatory

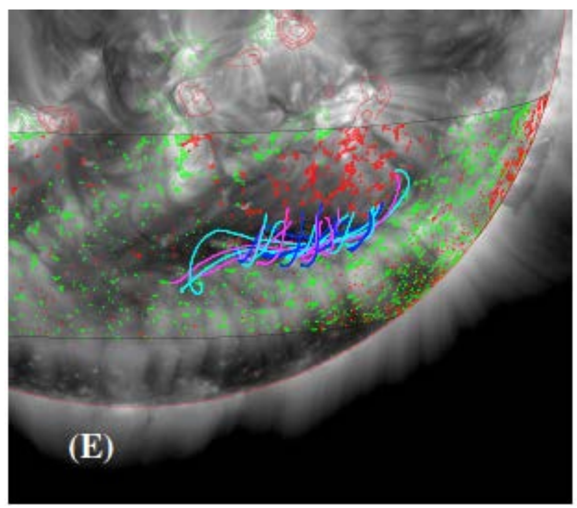
Hinode Highlights: Coronal Cavity Structure





- IRIS observations show areas of decreased Si IV emission along the neutral line, indicating the presence of a "bald patch" magnetic configuration, where fields have a concave-up shape near the Sun's surface.





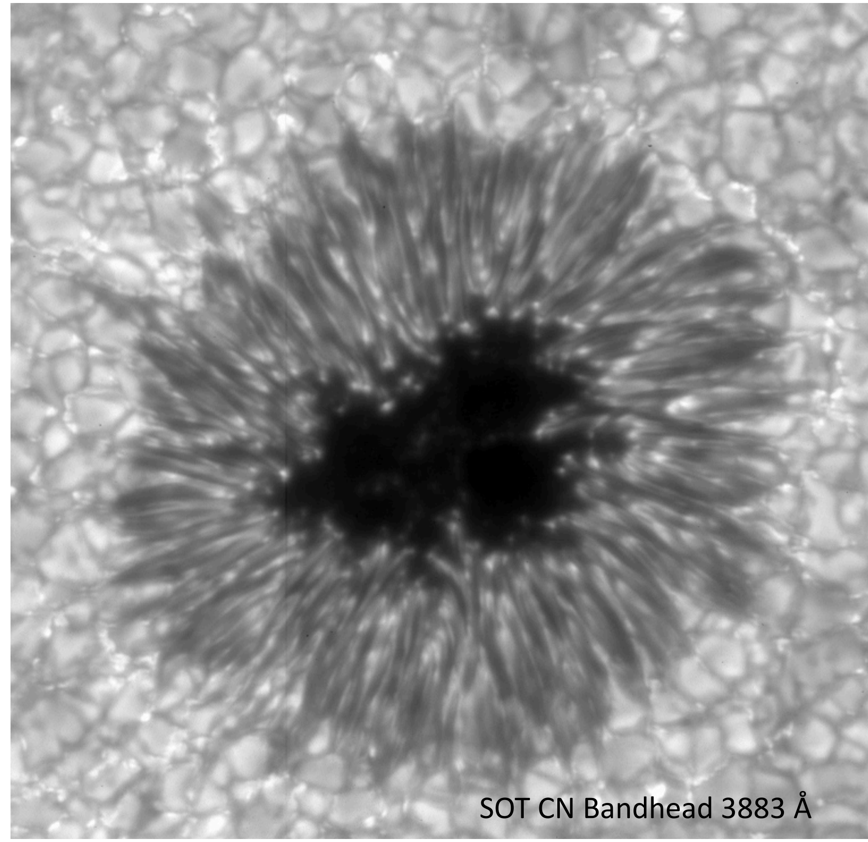
- Modeling shows that a weakly twisted magnetic flux rope is consistent with the observations for this cavity, including the existence of a "bald patch" at the neutral line.

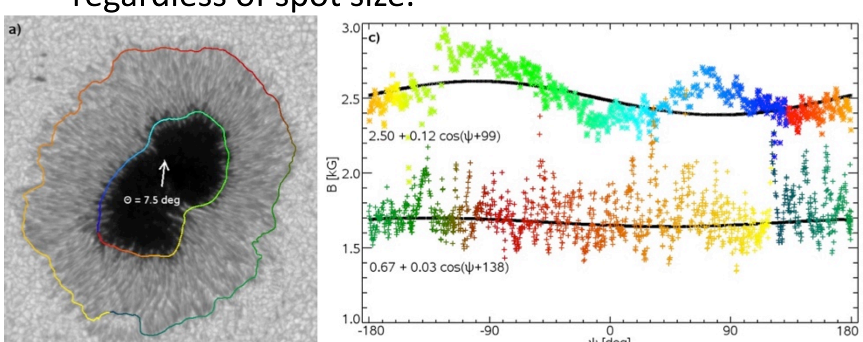
Jibben, Reeves, & Su, *Frontiers in Astronomy and Space Sciences*, submitted

Via the Hinode/XRT team through the Smithsonian Astrophysical Observatory

Hinode Highlights: Sunspot Magnetic Fields 100 Years Later

- What determines the boundary between Umbra and Penumbra?
  - Intensity? Flow field? Magnetic Field?
- Prior to 2011, 103 years after Hale's discovery of sunspot magnetic fields, no magnetic property for the boundary was found.
- Jurcak (A&A 2011): "The vertical component of the magnetic field [at the boundary] is possibly independent of the umbral area."
- A larger survey in 2015 has confirmed this and found a canonical value for B_{ver} at the boundary.
- For B_{ver} > 1860 Gauss, the efficiency of convection is suppressed and dark umbra results, with intermittent convective umbral dots.
- For B_{ver} < 1860 Gauss, the unique mode of penumbral magneto-convection takes over: penumbral filaments with the same brightness and flow structure regardless of spot size.



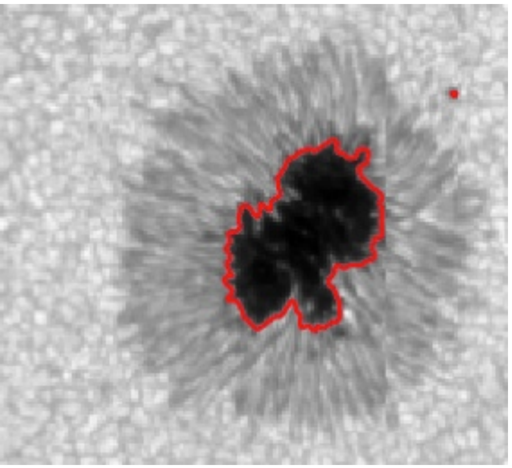


Why did it take 100 years to find this?

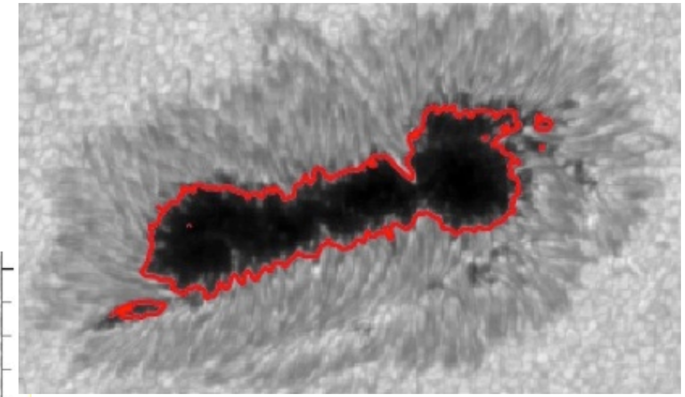
- Measured magnetic fields depend on instrumental characteristics, especially seeing and stray light.
- Hinode Spectro-Polarimeter measures all sunspots in an identical way with uniform point spread function and pointing stability.

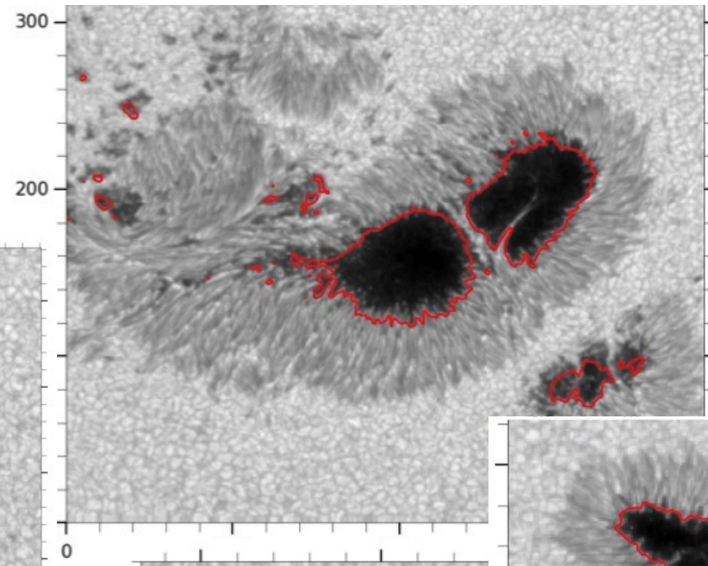
Contributed by the Hinode/SOT team through the Lockheed Martin Solar Astrophysical Laboratory

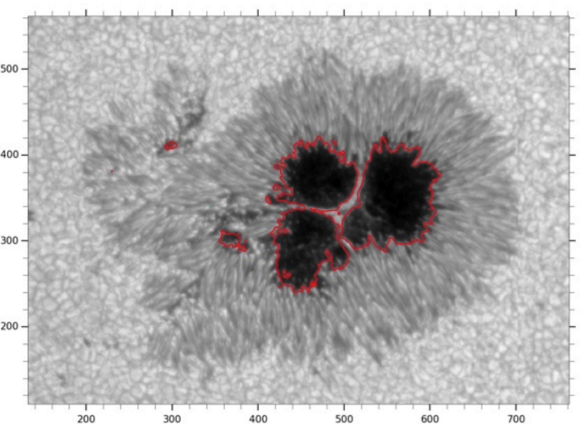
Hinode Highlights: Sunspot Magnetic Fields 100 Years Later

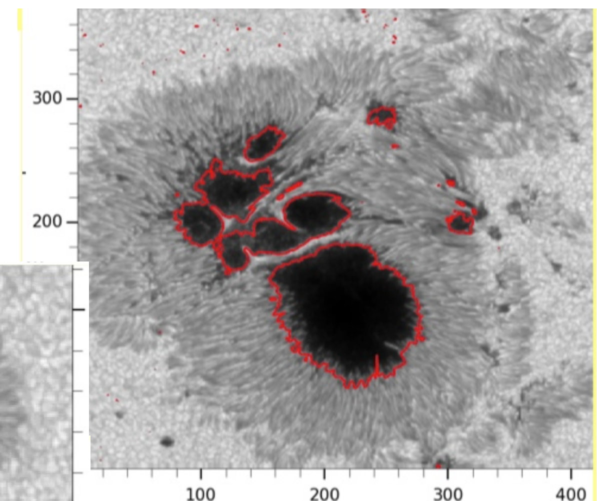


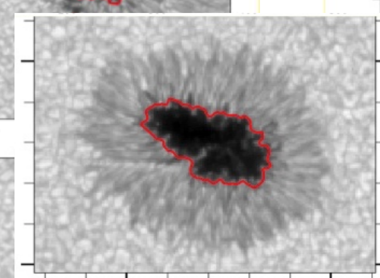
The canonical value of B_{ver} is confirmed for spots of all shapes and sizes, as long as they have stable penumbra.

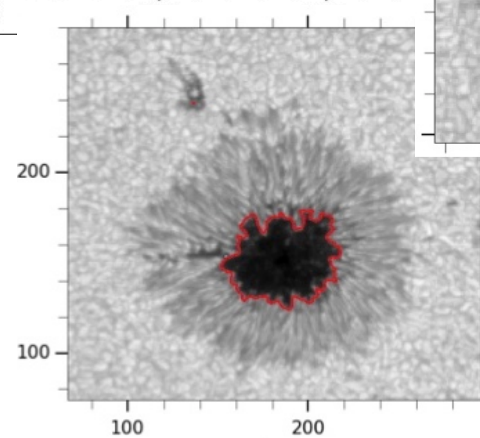


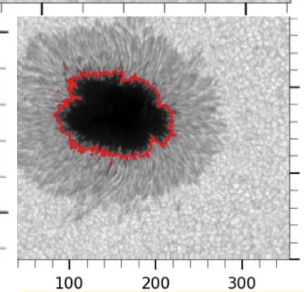


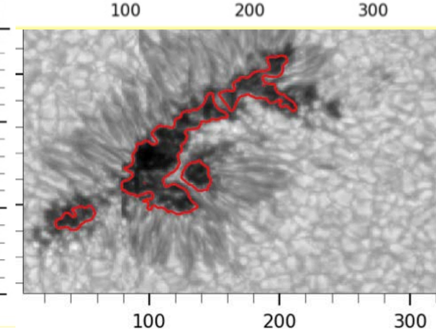












Sunspots from the Hinode SP Level-2 archive, showing the 1860 Gauss contour in B_{ver} (Schlichenmaier, 2015)

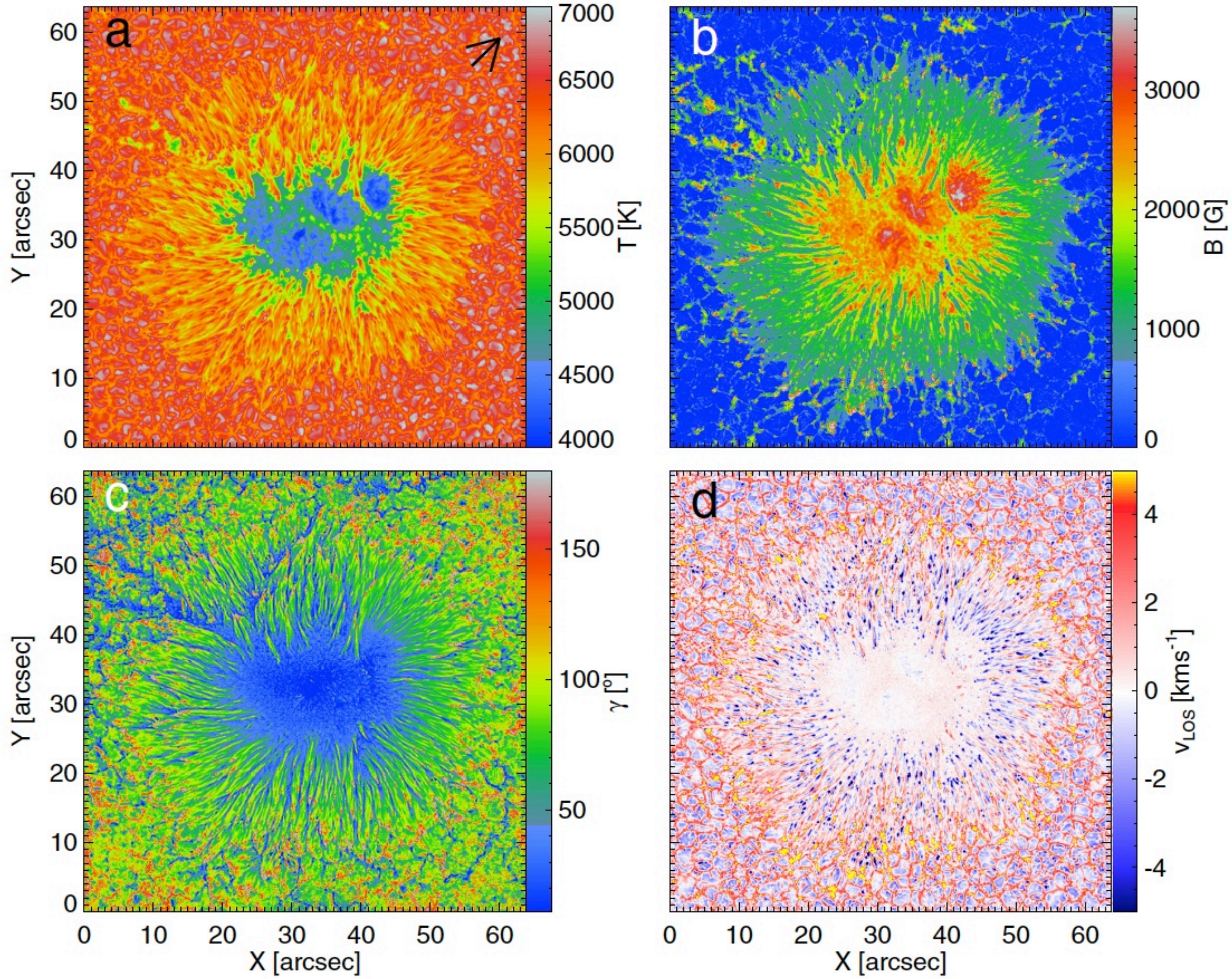
Contributed by the Hinode/SOT team through the Lockheed Martin Solar Astrophysical Laboratory

Hinode Highlights: Sunspot Magnetic Fields 100 Years Later

Modern Computational Power Applied to Spectro-Polarimeter Data

- A clever new technique solves a massive spatially-coupled optimization problem to make best estimates for the atmospheric parameters (**B**, V, T, etc.) at each point, correcting for the blurring by diffraction. The maps show small-scale structures sharper than in the original data (van Noort, A&A 2013).

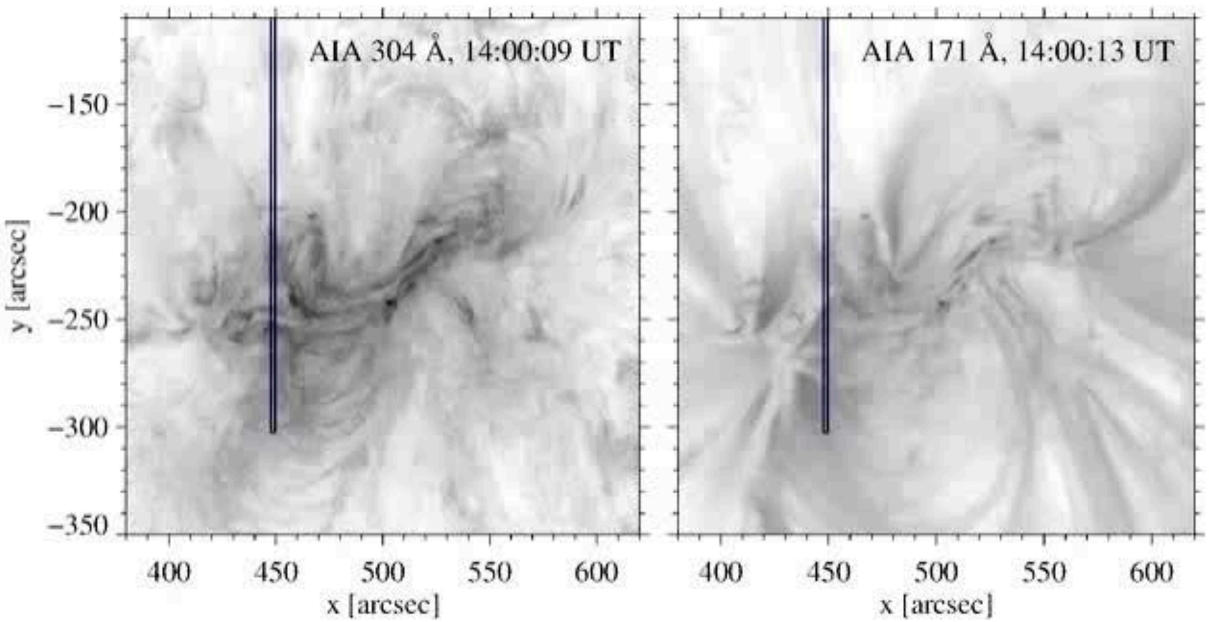
- Recent application by Tiwari et al (A&A 2015) not only derives the sharpest maps ever made of sunspot properties but also measures the depth dependence of temperature, velocity, and magnetic field strength, inclination and twist.

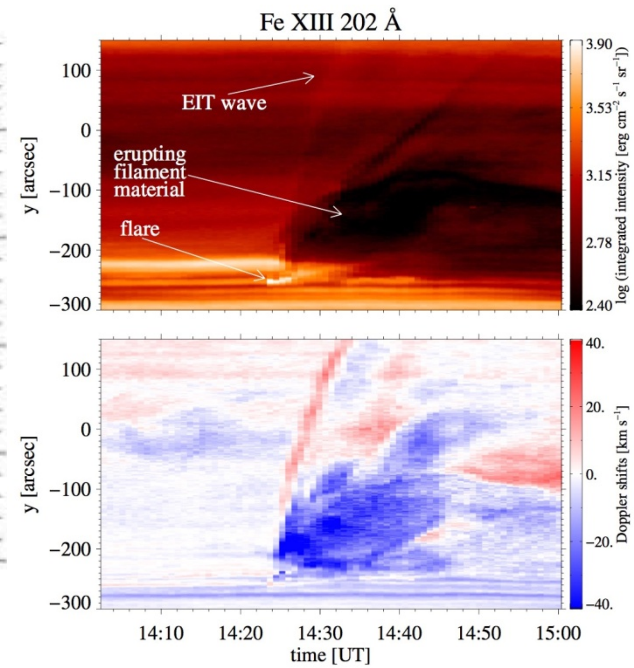


a) Temperature; b) Magnetic Field Strength; c) Magnetic inclination angle from vertical; d) Doppler velocity; all at tau = 1 in the photosphere.

Contributed by the Hinode/SOT team through the Lockheed Martin Solar Astrophysical Laboratory

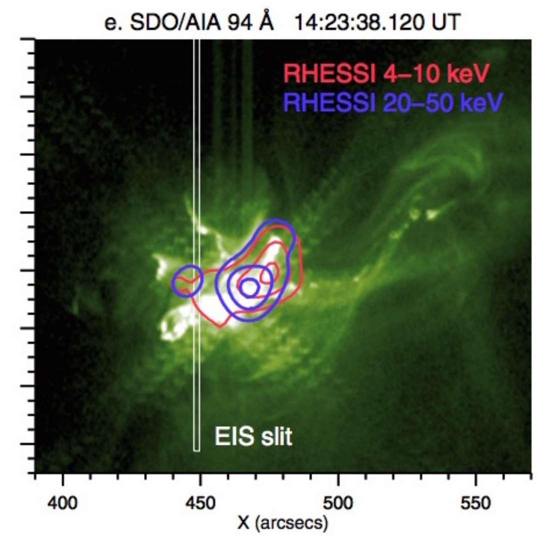
Hinode Highlights: Chromospheric Evaporation During Flares





Chromospheric Evaporation Flows and Density Changes Deduced from Hinode/EIS During an M1.6 Flare

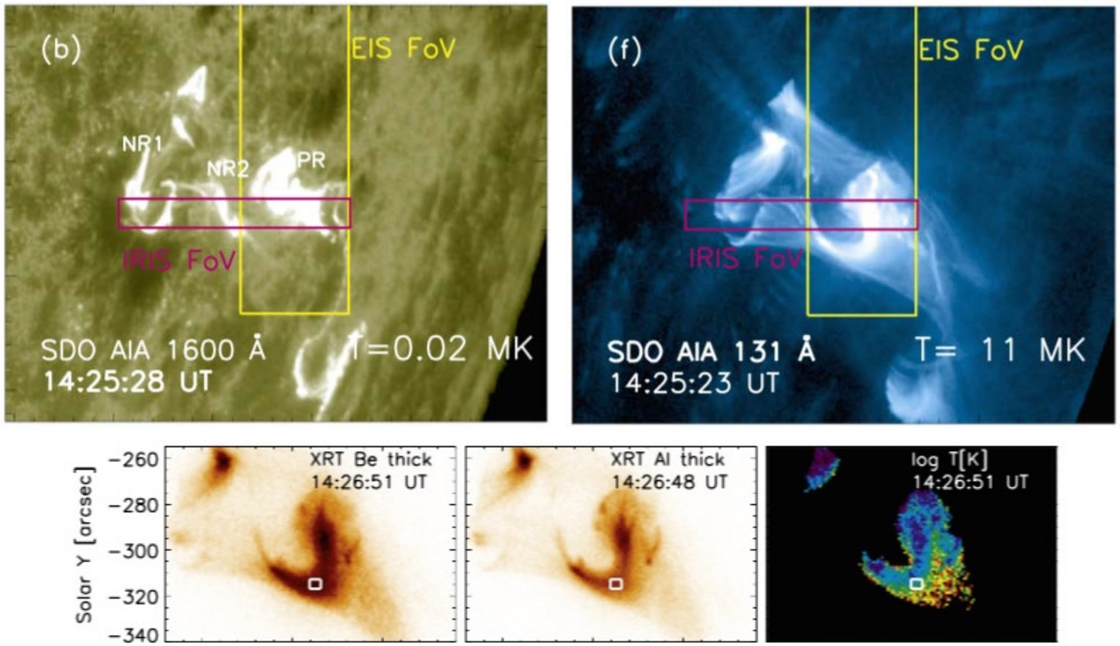
Gomory, Veronig, Su, Temmer, Thalmann, A&A, A6, 2016



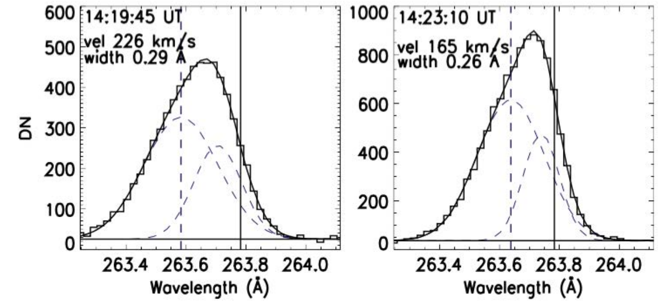
- Observations of an M1.6 flare with Hinode/EIS, SDO/AIA, and RHESSI
- EIS Doppler shifts and electron densities are compared with the energy flux measured with RHESSI
- Spectroscopic results support explosive chromospheric evaporation and show the dependence of the upflow velocity on the steepness of the energy distribution

Contributed by the Hinode/EIS team through the Naval Research Laboratory

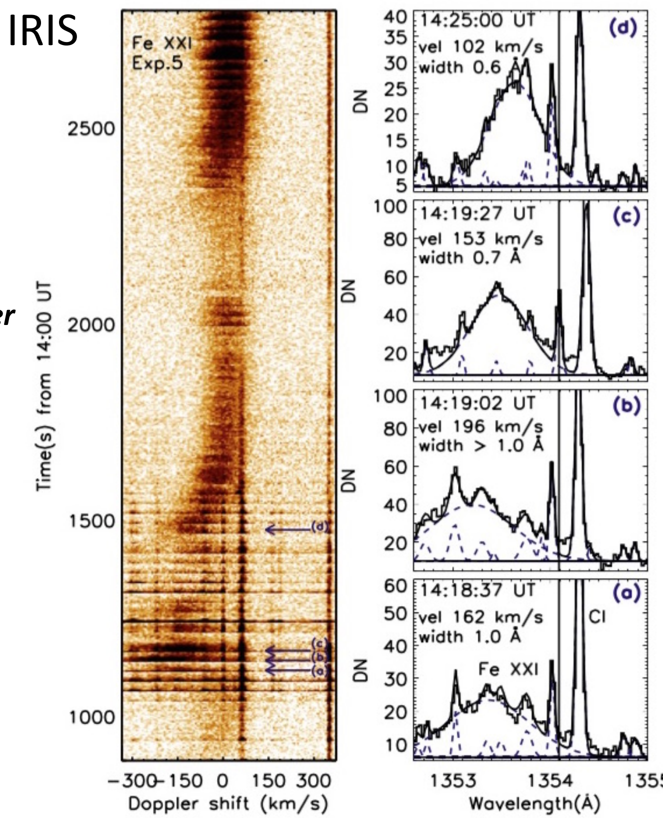
Hinode Highlights: Chromospheric Evaporation During Flares



EIS



IRIS



Simultaneous Iris and Hinode/EIS Observations and Modeling Of The 2014 October 27 X2.0 Class Flare

Polito, Reep, Simones, Dudik, Del Zanna, Mason, and Golub, ApJ, 816, 2016

- Observations of an X2 flare with Hinode/EIS+XRT, IRIS, SDO/AIA, and RHESSI
- High temperature line profiles in EIS generally show both a blue wing and stationary component but are completely blueshifted in IRIS, suggesting that evaporation is resolved with IRIS.
- Hydrodynamic simulations support an electron beam heating model.

Contributed by the Hinode/EIS team through the Naval Research Laboratory

Transit of Mercury – May 9, 2016

Hinode's Solar Optical Telescope (SOT) captures images of magnetically driven structures on the solar surface with its high-resolution Spectro-Polarimeter (SP), which uses a slit to disperse light. SOT/SP images are created by either scanning a region with a slit (rastering mode) or by allowing a region to drift past the slit as the Sun rotates (sit and stare mode).

By scanning the slit across a region where Mercury was expected to traverse, SOT captured this beautiful image of the planet in front of solar granules (roughly the size of Texas) on the Sun's surface. It took over 10 minutes to scan the full field of view with 512 vertical slits. Because Mercury moved while it was being scanning, the planet appears elliptical.

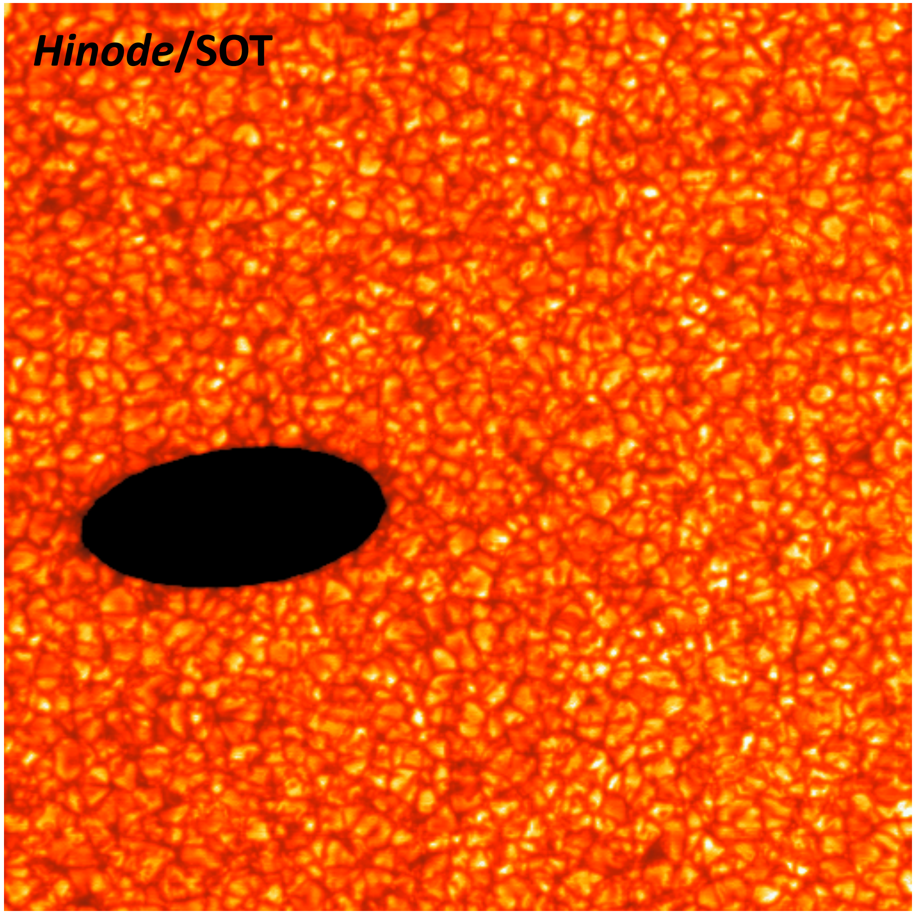


Image credit: JAXA/NASA/Lockheed Martin Solar and Astrophysics Laboratory (LMSAL)

Transit of Mercury – May 9, 2016

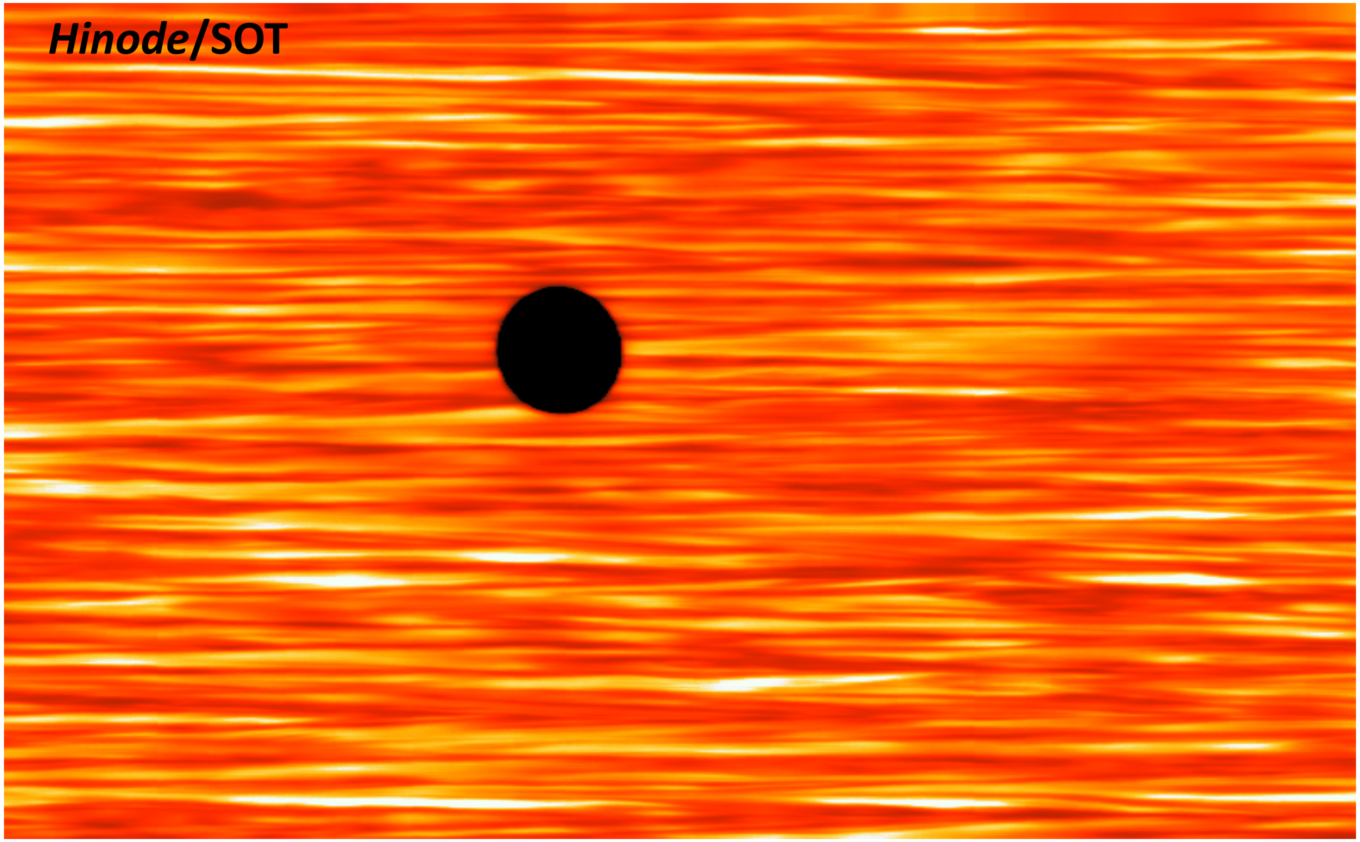
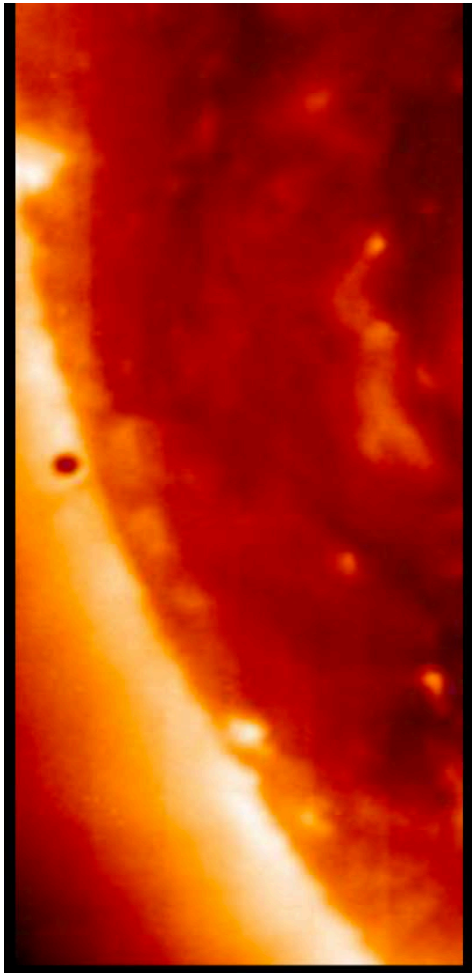


Image credit: JAXA/NASA/LMSAL

For this stunning image, the slit was held in a fixed position while Mercury and the Sun drifted by over a period of 3.4 minutes. The image consists of 828 vertical strips, each one ~110 kilometers wide, that are stitched together. The background shows how the solar granules in the previous image change with time as convection causes material to flow up and down during the heating and cooling process.

Transit of Mercury – May 9, 2016



Hinode's Extreme ultraviolet Imaging Spectrometer (EIS) also creates images by rastering with a slit, but it is optimized to observe the hotter temperature solar material in the Sun's atmosphere. This image from EIS shows Mercury as it approaches the East limb of the Sun. The background solar image is centered on the Fe XII line (195 Å) and shows material that is over 1 million degrees Kelvin.

Image credit: JAXA/NASA/UKSA/Naval Research Laboratory (NRL)

Transit of Mercury – May 9, 2016

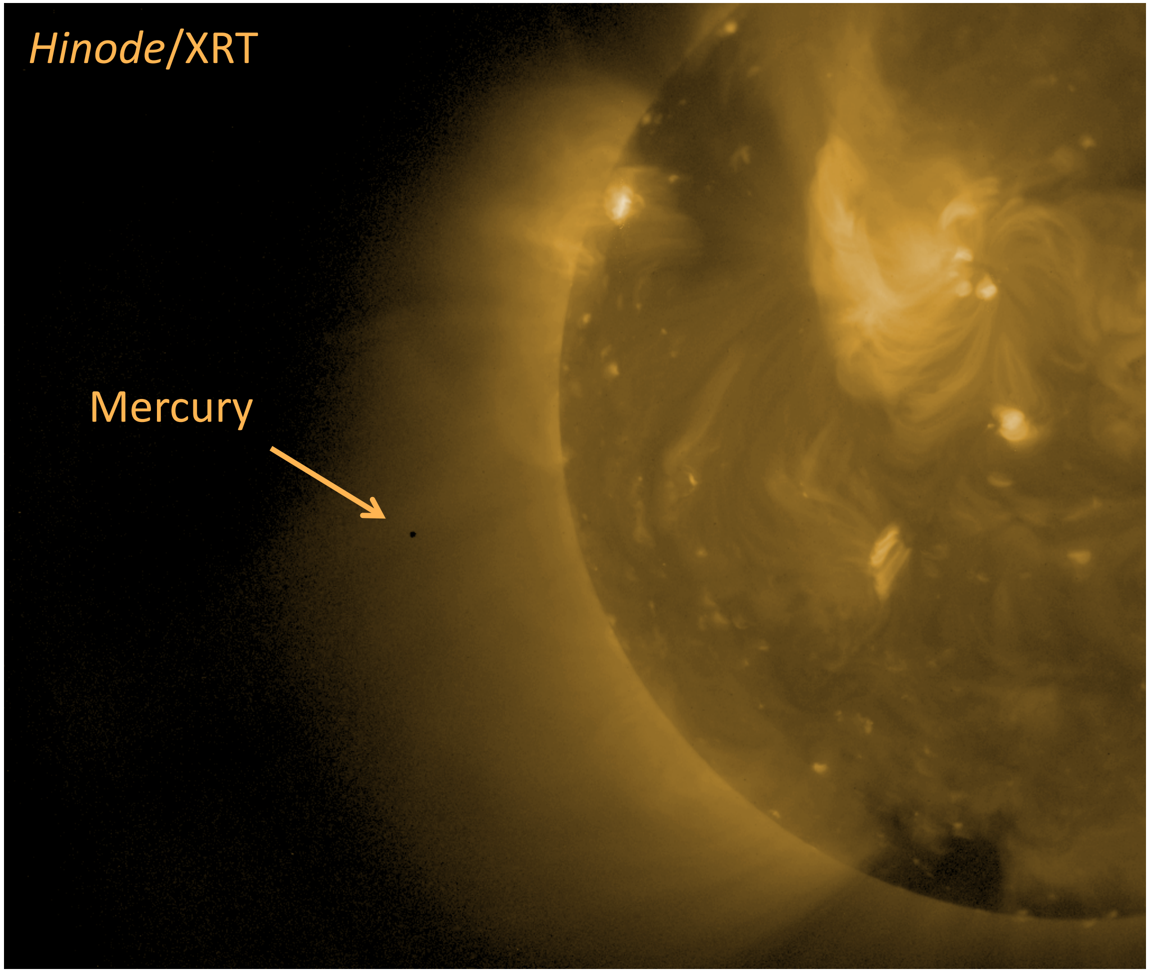
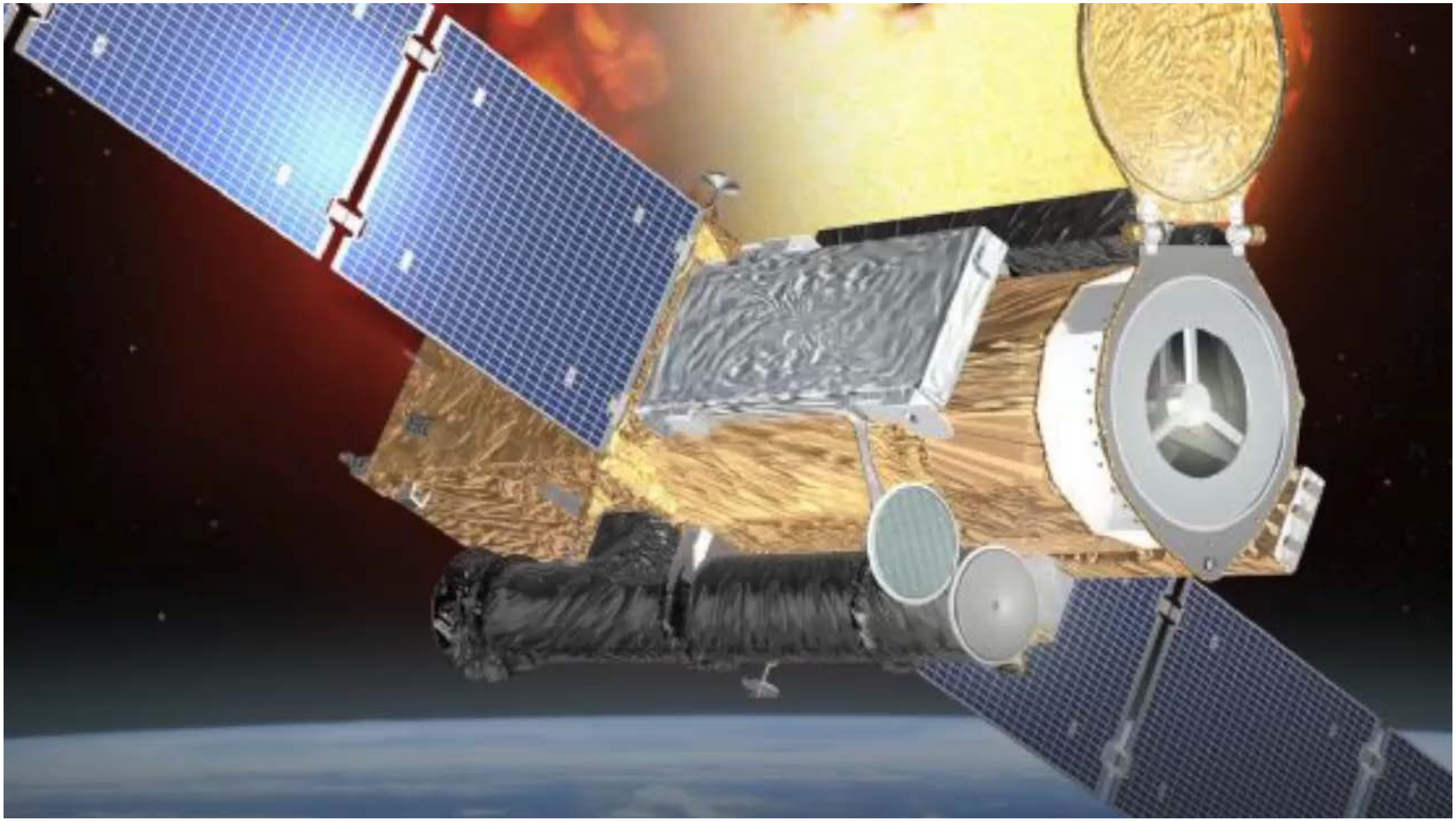


Image credit: JAXA/NASA/Smithsonian Astrophysical Observatory (SAO)

Hinode's third and final instrument, the X-Ray Telescope (XRT), is capable of taking full-Sun images of the hot solar atmosphere in soft X-rays.

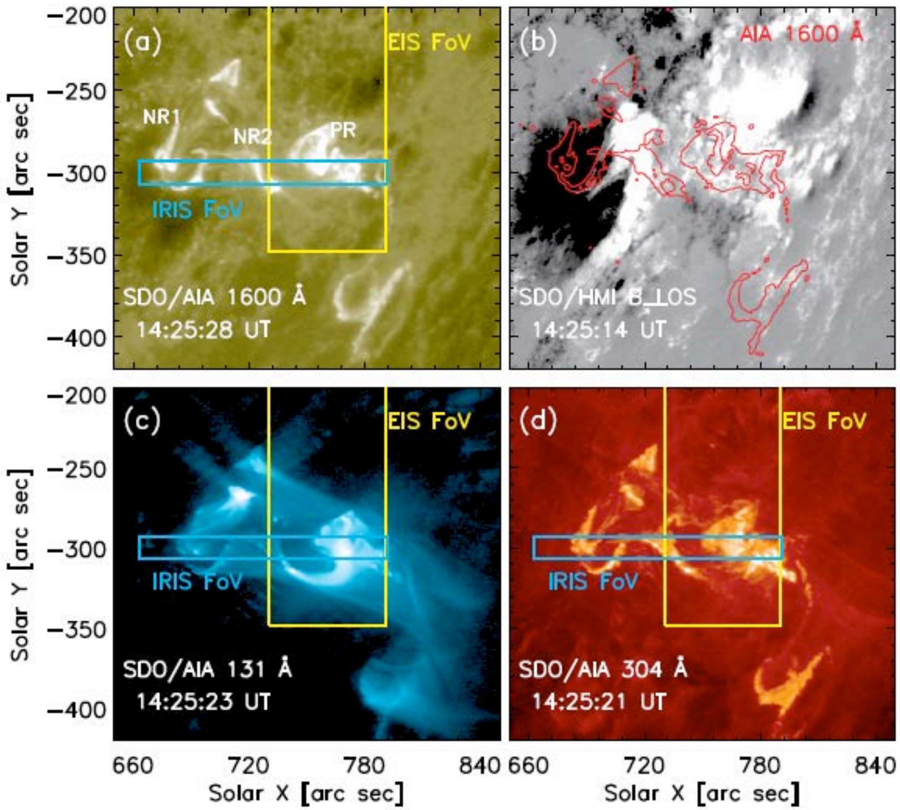
Transit of Mercury – May 9, 2016

Movie credit: JAXA/NASA/SAO/Montana State University

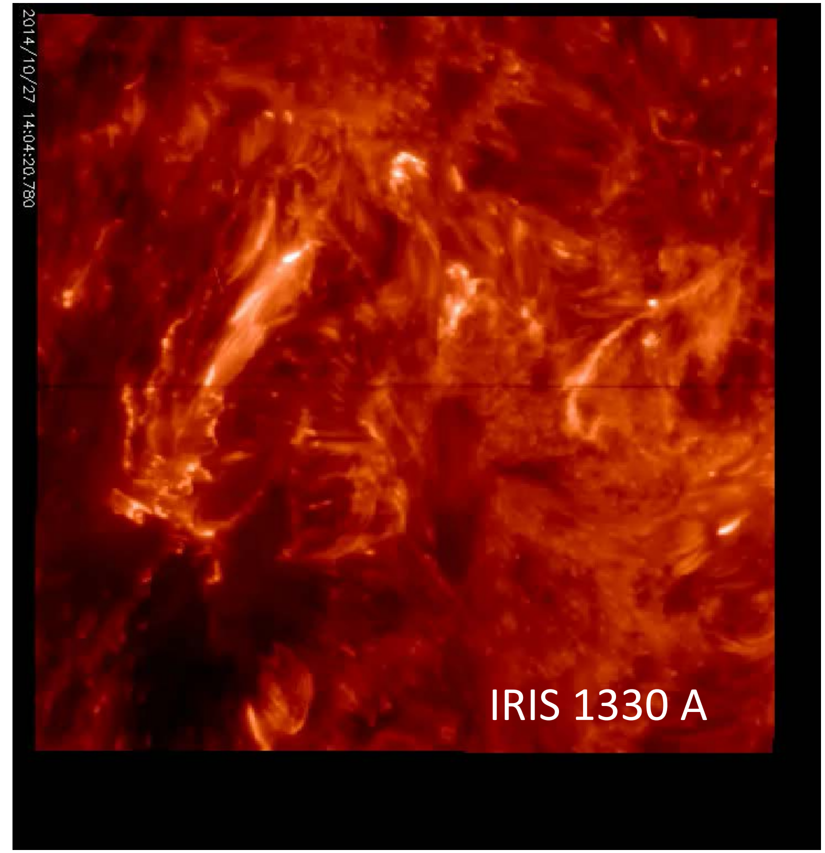


Using its Al-poly filter, which captures the light from coronal material at millions of degrees, XRT tracked Mercury from limb to limb. The slight apparent wobble of Mercury's path in front of the Sun is an optical effect called parallax caused by Hinode's orbit around the Earth from pole to pole.

Hinode Highlights: X2 flare on October 27, 2014

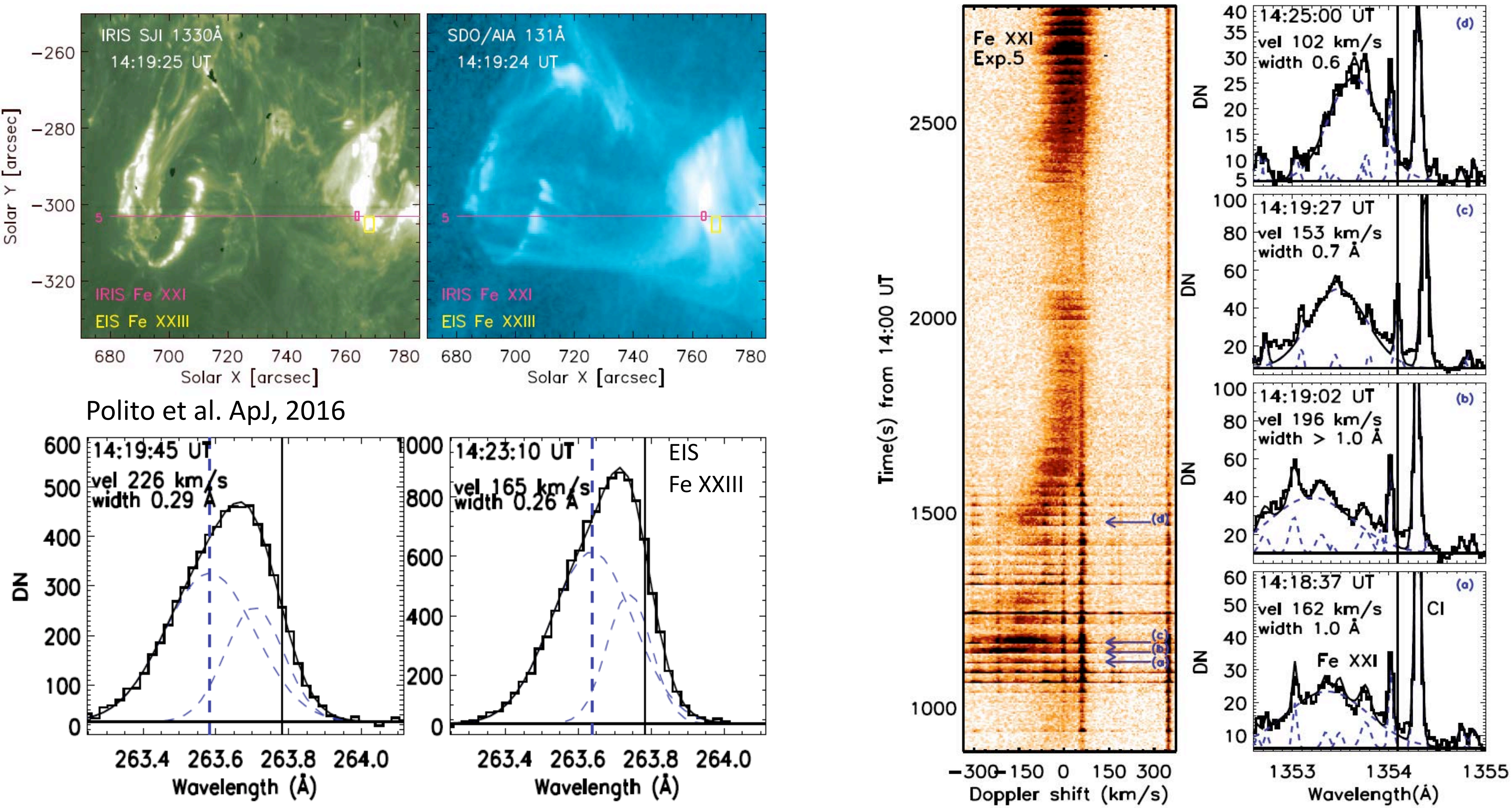


Polito et al. ApJ, 2016



On October 27, 2014, an X2 flare was observed with SDO, IRIS and Hinode. IRIS was rolled by 90 degrees, so the IRIS and EIS fields of view overlapped.

Hinode Highlights: X2 flare on October 27, 2014



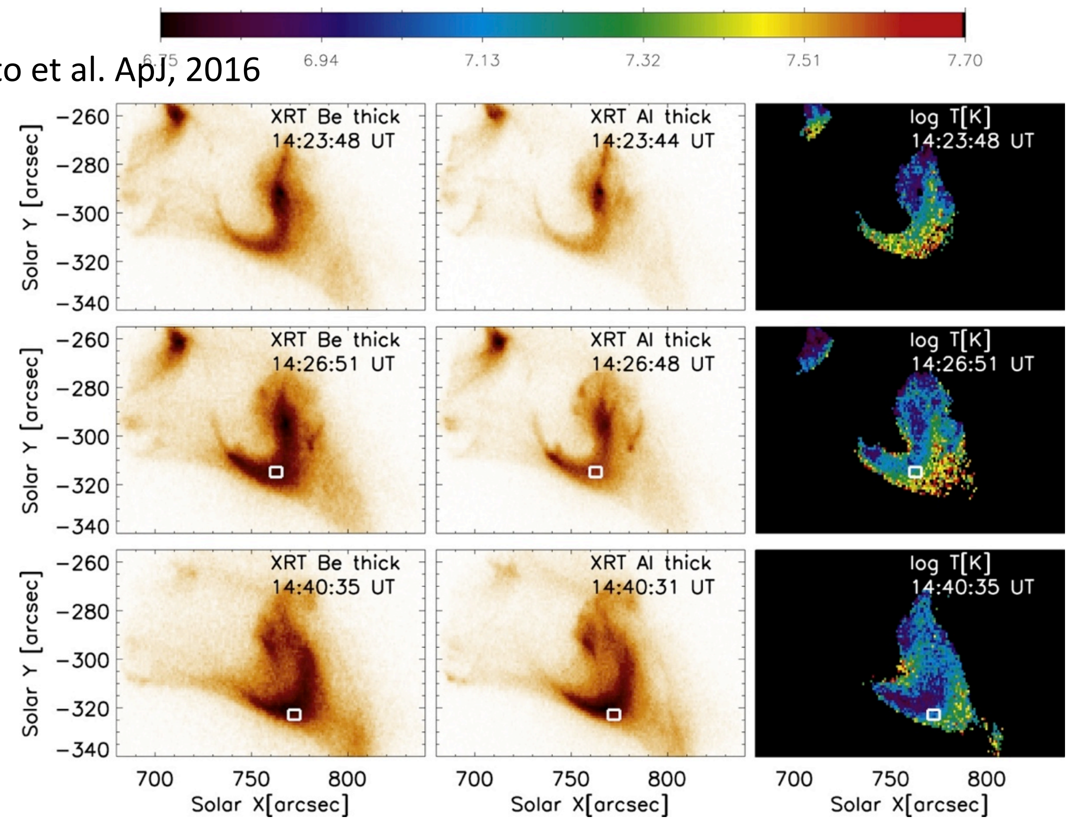
Polito et al. ApJ, 2016

Evidence for chromospheric evaporation: the EIS Fe XXIII line shows blueshifts of ~200 km/s. The IRIS Fe XXI line shows complete blueshifts (indicating flows are resolved), that decrease with time.

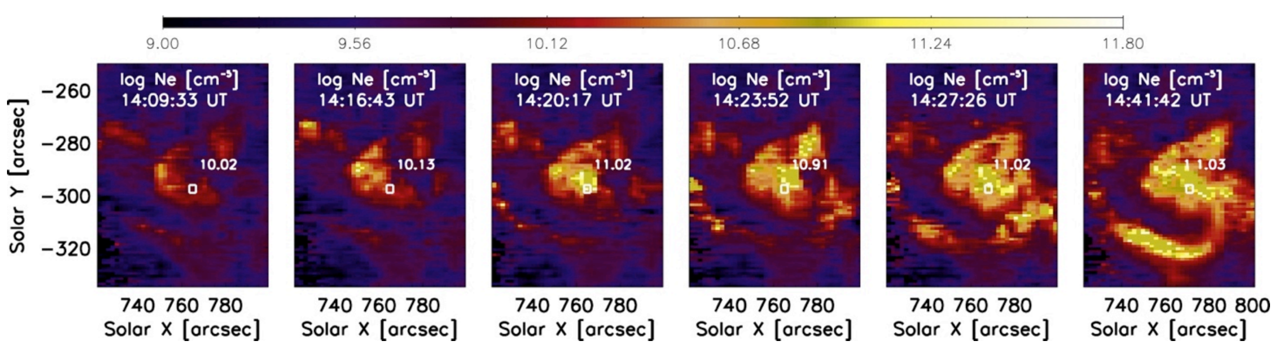
Via the Hinode/XRT team through the Smithsonian Astrophysical Observatory

Hinode Highlights: X2 flare on October 27, 2014

Polito et al. ApJ, 2016



- Temperatures from AIA and XRT show that hot emission (log(T[K]) > 7.2) is first concentrated at the footpoints before filling the loops.
- Density-sensitive lines from IRIS and EIS give estimates of electron number density of $\gtrsim 10^{12}$ cm^{-3} in the transition region lines and 10^{10} cm^{-3} in the coronal lines during the impulsive phase.

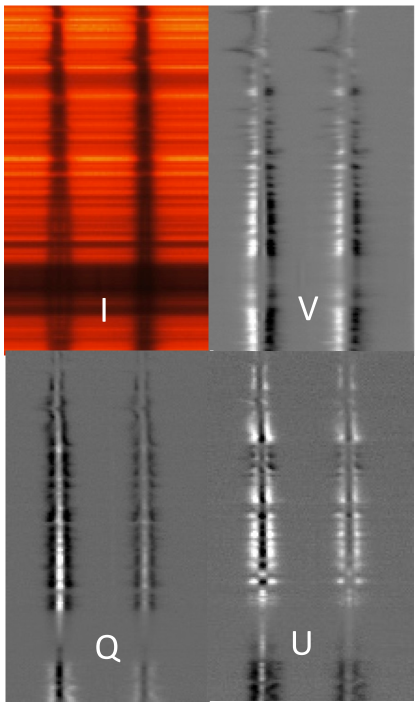


- Modeling indicates this data is consistent with an electron beam heating model rather than thermal conduction – key to distinguishing between flare heating sources

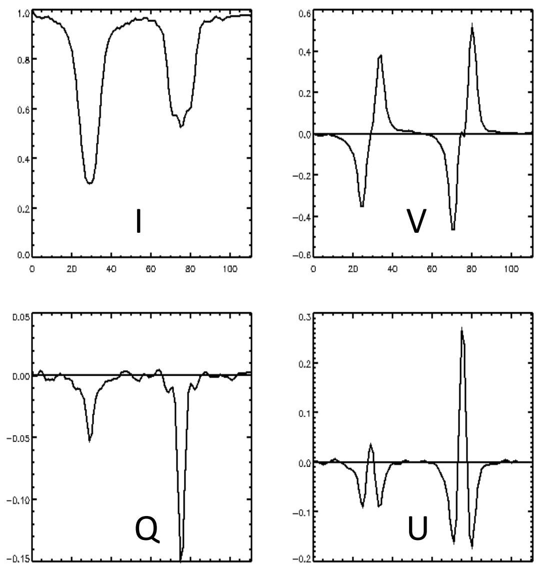
Via the Hinode/XRT team through the Smithsonian Astrophysical Observatory

Hinode Highlights: What is SOT doing now?

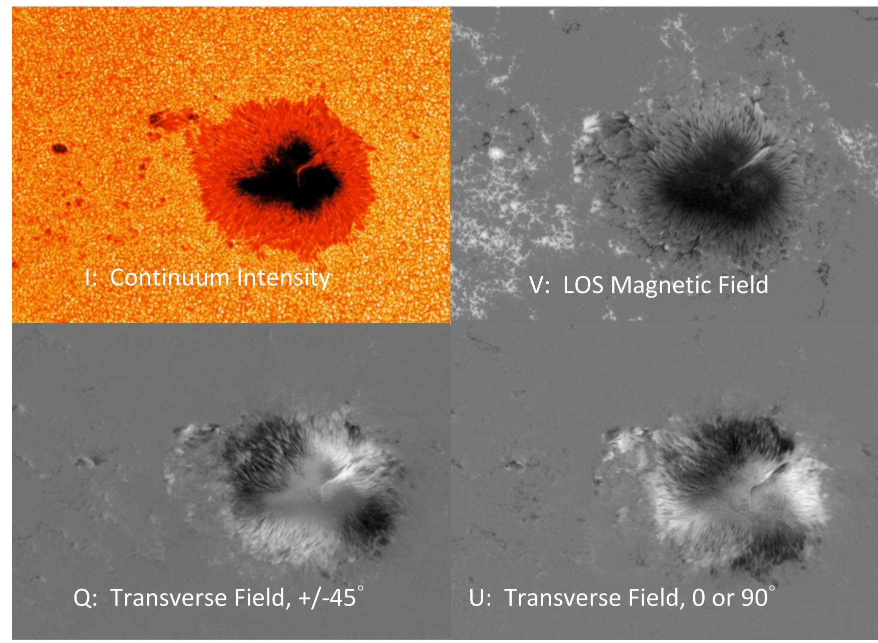
Since the Filtergraph camera failed in February, 2016, the Solar Optical Telescope's science instrument is now the Spectro-Polarimeter (SP), which is working nominally. These slides show what data it collects, both ongoing observations for almost 10 years and new modes enabled by additional telemetry and IRIS coordination.



Raw Spectra
(made onboard)



Calibrated Line Profiles
at a single pixel



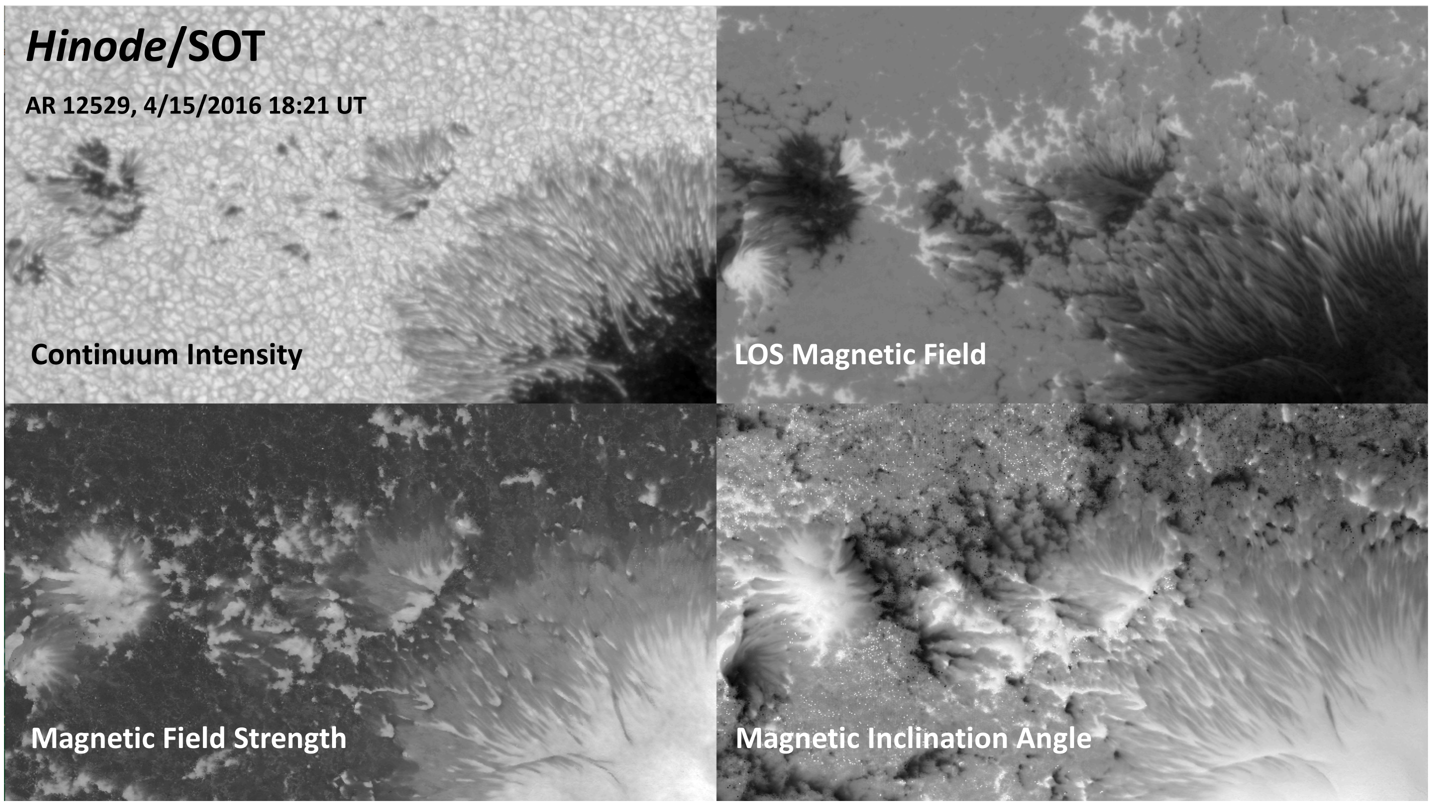
Images in the four polarization states,
the Stokes Parameters IQUV
AR 12529, 4/14/2016 12:45 UT

SP is a polarization-sensitive slit spectrometer. Its spectra are processed to make line profiles in two photospheric Fe I lines and Stokes images. Stokes QUV show the presence of magnetic fields in the atmosphere. Inversion of the line profiles makes maps of magnetic field vectors, Doppler shifts and other atmospheric thermal parameters.

Contributed by the Hinode/SOT team through the Lockheed Martin Solar Astrophysical Laboratory

Hinode Highlights: What is SOT doing now?

More telemetry is available now for SP and for XRT and EIS. As a result, SP can take more full-resolution spectra (0.16, not 0.32 arcsecond pixels). Few full resolution maps or time series have been made since the X-band failure in 2008, because the telemetry needed is 4x greater.

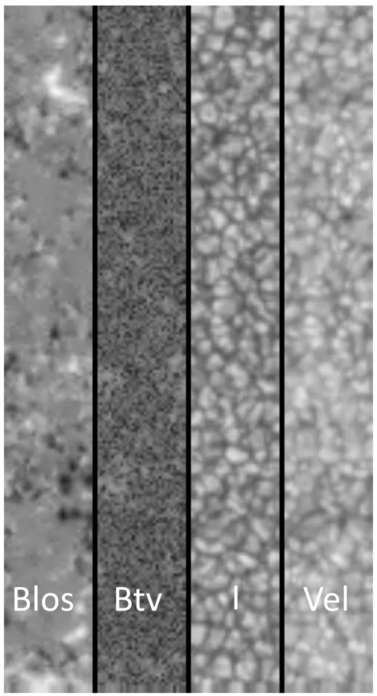


These full-resolution SP images show the mixed polarity region outside of a sunspot with the highest resolution and sensitivity available from any observatory. The bottom two images are derived by inversion of the Stokes spectra; the scattered noisy pixels are locations of very weak magnetic field where the inversion failed to converge.

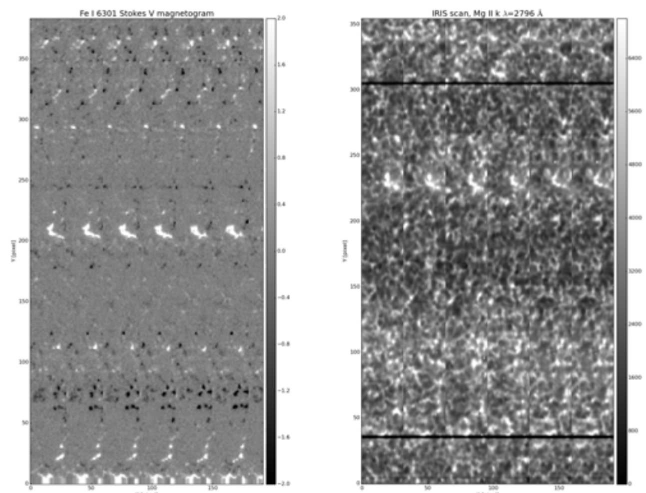
Contributed by the Hinode/SOT team through the Lockheed Martin Solar Astrophysical Laboratory

Hinode Highlights: What is SOT doing now?

Many IRIS & Hinode science goals require sensitive magnetic field measurements with high cadence, covering the IRIS slit. New SP observing programs make repeated tall, skinny maps with 0.5 – 20 minute cadence. With careful planning, the IRIS and SP raster areas overlap to ~2 arcsecond accuracy in the narrow dimension.

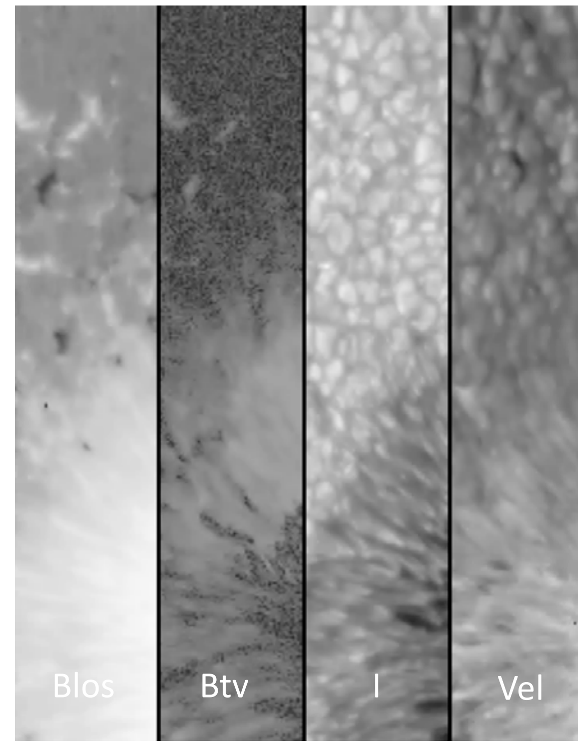


SP movies from a HOP 313 observation on June 13, 2016.
This goal is to search for chromospheric manifestations of super-sonic downflows seen in the photosphere.



Simultaneous SP magnetograms and IRIS Mg II spectrograph images of June 13. There is a vertical offset but alignment in the narrow horizontal dimension is good.

Both movies on this slide have 9 x 42 arcsecond FOV.



Full resolution SP movies from an IRIS & SOT study of explosive events in the mixed polarity outside of the sunspot on April 2, 2016.

Contributed by the Hinode/SOT team through the Lockheed Martin Solar Astrophysical Laboratory